The Burden of Asthma
in Washington State

Washington State Department of Health

Washington State Department of Health
Washington Asthma Initiative
June 2005

The Burden of Asthma in Washington State

June 2005

Division of Community and Family Health
Office of Community Wellness and Prevention

For more information contact:
Amy Manchester Harris MPA, Manager
Washington State Department of Health, Asthma Prevention Program
Chronic Disease Prevention and Risk Reduction
PO Box 47855, Olympia WA 98504-7855
Physical address: 111 Israel Road SE
Phone: (360)236-3851 Fax: (360) 236-3717

This report is posted on the Department of Health/American Lung Association of Washington web sites in a .pdf format. The main website addresses are: http://www.doh.wa.gov and http://www.alaw.org.

For persons with disabilities this document is available on request in other formats. To submit a request please call 1-800-525-0127 (TDD/TTY 1-800-833-6388).

Mary C. Selecky
Secretary of Health

Maxine Hayes, MD MPH
Health Officer

Patty Hayes, MSN BSN
Assistant Secretary, Community and Family Health

Linc Weaver
Office Director, Community Wellness and Prevention

Mary Frost
Director, Chronic Disease Prevention and Risk Reduction

Suggested Citation:
Dilley JA, Pizacani BA, Macdonald SC, Bardin J. The Burden of Asthma in Washington State. Washington State Department of Health. Olympia, WA. June 2005. DOH Pub No. 345-201.

Report Funding:
Funding for this report was provided by the Washington State Department of Health and the Centers for Disease Control and Prevention (U59/CCU020839-02).

Centers for Disease Control and Prevention Project Officer and Epidemiology consultation provided by:
Liane Hostler, RN; Air Pollution and Respiratory Health Branch National Center for Environmental Health
Clive Brown, M.B.B.S., M.P.H., Air Pollution and Respiratory Health Branch National Center for Environmental Health

Collaboration with Dr. Pizacani was supported in part by the Washington State Tobacco Prevention and Control Program.

Acknowledgements

The Burden Report was developed by the Department of Health in close coordination with the Washington Asthma Initiative, including the Data and Surveillance Workgroup.

Authors

Julia Dilley, PhC, MES
Washington State Department of Health – Chronic Disease Prevention & Risk Reduction
Barbara Pizacani, PhD, MPH, RN
Oregon Department of Health and Human Services – Multnomah County Health Department
Steven Macdonald PhD, MPH
Washington State Department of Health – Office of Epidemiology
Judy Bardin, ScD, MS, RN
Washington State Department of Health – Environmental Health Assessment

Final formatting, layout and proofing by Hallie West, BA

Contributors

Washington State Department of Health

Barbara Baker, Office of Epidemiology
Nancy P. Bernard, MPH, Environmental Health and Safety
Linda Gunnells MSPH, Steps to a HealthierWA/Asthma Program
Amira El-Bastawissi, MBCHB, Ph.D, Community Wellness & Prevention
Craig Erickson, Division of Information Resource Management
Karen E. Krueger, RN, MN, MBA, Chronic Disease Prevention & Risk Reduction
Amy Manchester Harris, MPA, Asthma Program Manager
Craig Parker, Tobacco Prevention & Control Program
Glen Patrick, MPH, Environmental Health Assessment
James VanDerslice, PhD, Environmental Health Assessment
Shanae Williams, Tobacco Prevention & Control Program

Harriet M. Ammann Ph.D., D.A.B.T., Washington State Department of Ecology/Air Quality Program
Doris Cordova, Oregon Department of Health and Human Services/Multnomah County Health
Christy C. Curwick, MPH, Washington State Department of Labor and Industries/SHARP Program
Jason Debley, MD, MPH, Children's Hospital and Regional Medical Center
Robin Evans-Agnew, RN, MN, AE-C, American Lung Association of Washington
Laird Harris, Harris and Smith Public Affairs
Sue Lankow, RN, Med, Office of the Superintendent of Public Instruction
Rick MacCornack, Ph.D. Northwest Physicians Network
Julie Maher, PhD,MS. Oregon Department of Health and Human Services/Multnomah County Health
Rich Prill, Washington State University Energy Program
Gail Shapiro, MD, Northwest Allergy & Asthma Center
Lin Song, Ph.D, Public Health – Seattle & King County
Sean D. Sullivan, R.Ph., PhD University of Washington Department of Pharmacy/Washington Asthma Initiative Chair
John Thayer, R.S., Yakima Valley Farm Workers Clinic
Gayle Thronson, RN, MEd, Office of the Superintendent of Public Instruction
Vickie Ybarra, RN, MPH, Yakima Valley Farm Workers Clinic

Table of Contents

List of Figures

The Burden of Asthma in Washington State: Executive Summary

In Washington State…

Asthma is an important issue for people concerned about the public's health

- Although death from asthma is uncommon – about 100 people per year die in Washington each year from asthma – treatment of asthma places a significant economic burden on the public and symptoms of asthma place a substantial burden on affected individuals and their families
- More than 5,000 people are hospitalized every year – more than 100 every week – as a direct result of asthma; more than half the hospitalizations are paid for by Medicare or Medicaid
- Direct medical costs for asthma in Washington are about $240 million each year
- In total, asthma costs more than $400 million every year in medical expenditures and lost productivity for the state
- Between 1995-2002 more than a thousand claims were paid by state worker compensation funds for work-related asthma totaling $12 million
- Having asthma reduces quality of life, limits activities, and is associated with depression and suicidal thoughts among young people
- About 48,000 adults with asthma make at least one emergency department visit per year and 100,000 make at least one urgent visit to see their doctors for worsening asthma symptoms each year
- More than 75% of adults and youth with asthma had symptoms during the past month – these include cough, wheezing, shortness of breath, chest tightness and phlegm; half of adults and one-third of youth had trouble sleeping because of their symptoms
- Youth with asthma miss school because of their condition, and those with more severe asthma symptoms are less likely to have high academic achievement than youth with few symptoms or those without asthma.

A large and growing number of people are affected by asthma

- About 400,000 Washington adults – one in ten women and one in fourteen men – currently have asthma
- About 120,000 Washington youth are currently affected by asthma
- The percentage of our state population with asthma is steadily increasing - the prevalence of asthma has increased significantly for adults and households with children between 1999 and 2003
- Washington's asthma prevalence has been identified by CDC as one of the highest in the nation – both adult and youth prevalence are significantly greater than national averages
- About 9% of adults have asthma, between 7-10% of middle/high school-aged children have asthma, and one in ten households with children of any age have a child with asthma.

Development of asthma is associated with individual factors – some can be controlled, and others can't

- Among young children, asthma prevalence is higher for boys than for girls; by middle school age these differences reverse so that by high school and in later years rates are higher for women than for men
- People who smoke cigarettes or who are obese are significantly more likely to have asthma than people who do not smoke or are not obese
- Younger youth who use inhaled intoxicants, marijuana or cigarettes are significantly more likely to have asthma than youth who do not
- Many people who develop asthma have allergies, particularly those with childhood onset of asthma
- Some people are genetically more vulnerable to developing asthma than other people
- Hospitalization rates are highest for children under age 5, but death rates are highest for people older than 65.

People with asthma need better access to healthcare and healthcare providers need more guidance about what quality care for asthma includes

- Deaths attributed to asthma have been declining since the mid-90s, most likely in response to successful clinical practice improvements
- More than one in ten people with asthma have severe persistent symptoms – frequent exacerbations and continuous symptoms
- People with asthma are more likely than people without asthma to report they had unmet healthcare needs – times when they wanted to see a doctor but couldn't due to a lack of money
- About half of adults and youth with asthma reported seeing a healthcare provider in the past year for a planned preventive asthma visit
- Only one-third of youth with asthma reported ever having a written asthma plan to help them control their medications and exposures
- About three in ten seniors with asthma have not received flu and pneumonia vaccines, a recommended component of healthcare for asthma patients but also for all seniors in general
- Only one in ten smokers with asthma reported receiving advice to quit from a doctor during the past year, which is also a recommended component of healthcare for asthma patients
- About three-quarters of people with asthma are taking some kind of medication, about one-third of people with asthma are using medication twice or more per day
- School nurses need continued and increased support to manage thousands of children with life-threatening asthma in Washington schools
- Healthcare providers, including school nurses and staff, should be aware that people with asthma are more likely to have other chronic conditions such as diabetes, hypertension (adults), depression, and suicide ideation (youth); multi-component treatment strategies may be necessary.

Things in your environment can cause asthma or make asthma worse

- Exposure to secondhand smoke causes asthma in children – more than 40,000 children ages 5 or younger in our state are exposed to secondhand smoke at home – about 500 new cases of asthma each year are caused by exposure to secondhand smoke
- There is sufficient evidence for a causal relationship between exposure to dust mites and development or exacerbation of asthma – most houses contain habitats for mite growth such as mattresses, pillows, bedding, stuffed animals
- There is sufficient evidence that other indoor air contaminants such as cat, dog, and cockroach allergen, woodsmoke, damp environments and mold in damp environments make asthma worse
- A substantial number of people with asthma have "triggers" in their homes that they may not realize make their asthma worse – carpet, pets, cockroaches, water damage, secondhand smoke and mold
- Air pollution exposure, including from fine particulate matter, nitrogen oxides, carbon monoxide, sulfur dioxide, diesel exhaust, and woodsmoke makes asthma worse and ozone causes new asthma.

People responsible for community, worksite, school, and housing environments can make a difference to prevent and reduce the burden of asthma

- Asthma is affected by outdoor air quality – outdoor air quality is improving, but still affected by mobile vehicle exhaust (cars, buses, trucks, ships and trains), woodstoves, outdoor burning, and industrial emissions
- Although Washington's air quality is generally good and has improved substantially over time, there are areas of the state where air pollution is of concern and higher rates of hospitalization in urban areas may be related to asthma exacerbation from air pollution
- The proportion of adult-onset asthma that can be attributed to workplace exposures has been estimated to be between 5-25%; occupational exposures are very different for different occupations, but secondhand smoke is an asthma trigger that many workers are still exposed to
- Asthma is worsened by secondhand smoke exposure – smoking is still allowed in some worksites, including worksites where the public can visit and also be exposed, such as restaurants, bars, and casinos
- Poor air quality at school exacerbates asthma and is also associated with decreased student attendance in the general population – air in or around schools may be affected by management of ventilation and filtration systems, cleaning practices, reduction of "idling" by school bus engines or others waiting to pick up students, and retrofitting school buses with particle filters or oxidative catalytic converters
- Asthma among children is caused or worsened by secondhand smoke exposure, and smoking occurs in many homes – one in ten youth lives in a home where smoking is allowed, and almost one in ten non-smoking adults with asthma is exposed to smoking at home.

Some people are unfairly affected by asthma as a result of societal inequities

- Asthma hospitalization rates are higher in urban areas than in rural areas
- Low income people and those with the least education are more likely to have asthma
- Lesbian/bisexual women have significantly higher rates of asthma than straight women or men
- Native Americans have higher prevalence of asthma than non-Hispanic whites, and both Native Americans and African Americans have significantly higher rates of death due to asthma than non-Hispanic whites.

We know what to do about asthma in Washington State

- Public health partners are developing a comprehensive State Asthma Plan to prioritize and implement strategies for reducing the burden of asthma in Washington State.

I. Introduction

The purpose of this report is to describe the burden of asthma in the State of Washington. In this report we explain why asthma is an important public health issue, describe who has asthma, and provide information about the quality of healthcare for people with asthma as well as information about environmental exposures that cause asthma or increase asthma attacks.

This information can be used to help prioritize asthma prevention and control within the spectrum of Washington public health concerns, as well as to provide information needed for asthma prevention and control planning throughout Washington State.

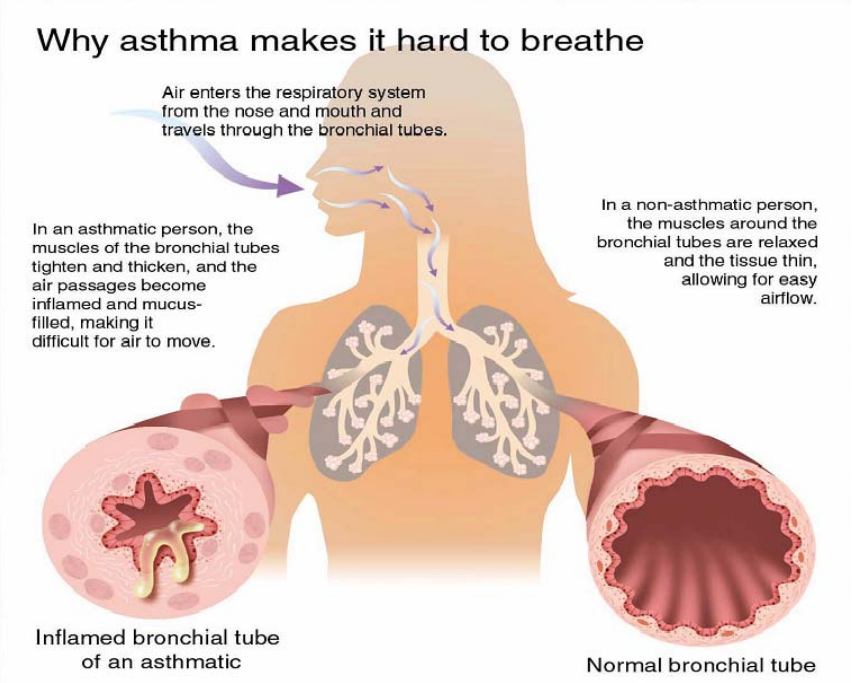
What is asthma?[*]

Asthma is a chronic inflammatory disorder of the airways which is associated with airway hyper-responsiveness, airflow limitation and respiratory symptoms. The American Thoracic Society definition for asthma is the most widely cited to describe asthma. They define asthma as a disorder with the following characteristics, not all of which need be present to assign the diagnosis of asthma.

Airway Obstruction
Narrowing that is reversible (but not completely so in some patients) either spontaneously or with treatment.

Airway inflammation

Airway hyper-responsiveness to a variety of stimuli.



Printed with permission from the American Academy of Allergy, Asthma & Immunology. Copyright American Academy of Allergy, Asthma & Immunology, all rights reserved

Five key indicators for asthma diagnosis have been identified by the National Asthma Education and Prevention Program (NAEPP) expert panel, however, they are by

[*] Text to define asthma was primarily adapted from the *National Asthma Training Curriculum,* CD-ROM educational resource, Centers for Disease Control and Prevention, National Center for Environmental Health and the Academy of Allergy, Asthma and Immunology, August 2004.

themselves a diagnosis. If multiple indicators are present then it increases the probability of asthma. The key indicators of asthma are:

1. Wheezing, especially in children
2. History of cough (especially at night), recurrent wheeze, recurrent shortness of breath, difficult, labored breathing, or recurrent chest tightness
3. Reversible airflow limitation, happening at varied times during the day, that can be measured by using a peak flow meter
4. Symptoms that occur or worsen in the presence of exercise, viral infection, animals with fur or feathers, house-dust mites, mold, smoke, pollen, changes in weather, strong emotional expression, airborne chemicals/dusts, and/or menses
5. Symptoms that occur or worsen at night, awakening the patient.

Asthma Exacerbations

Attacks or worsening of asthma symptoms and lung function are acute and can have a rapid onset or can occur gradually over time.

Bronchial asthma in the untreated state is recognized by recurrent episodes of airflow limitation usually reversible spontaneously or with appropriate treatment. Symptoms of airway limitations can be breathlessness, wheezing, chest tightness and/or cough.

There are four forms of airflow limitation related to inflammation in the airways:

Airway Wall Swelling

In untreated asthma, the inner lining of bronchi and bronchioles becomes inflamed and thickened, causing narrowing of the central air passage.

Acute Bronchoconstriction

Bronchoconstriction is caused by contraction of the smooth muscle that surrounds the airways. Bronchoconstriction, or bronchospasm, is most likely to occur in the presence of intense inflammation. Such bronchospasm causes the openings in the air passages to narrow even more.

Chronic Mucus Plug Formation

The overproduction of mucus in the inflamed airway causes plugs. The plugs are comprised of mucus secretion, exuded serum proteins, and cell debris. This aggravates the airflow limitation caused by the other processes described.

Airway Remodeling

Airway remodeling refers to an alteration in the composition of the airway wall. It occurs in some patients, usually those with longstanding asthma. Normal components are replaced by less functional substances, similar to scar tissue replacing normal tissue. This form of airway obstruction may be persistent and may not respond to treatment.

Asthma can range from being an intermittent nuisance triggered by specific factors, such as allergen exposure or exercise, to being a severe, progressive, and occasionally fatal

disease without apparent external cause. This diversity has led to a growing appreciation that asthma, as currently defined, probably is not a specific disease, but a syndrome with multiple causes leading to a common clinical presentation involving reversible airway obstruction.

We know that family history contributes to susceptibility, but in most cases we don't know what causes asthma to develop, and we don't know how to cure asthma. People with asthma can control it by knowing the warning signs of an attack, avoiding things that trigger an attack, and following the advice and prescriptions of their doctor. When asthma is controlled people that have it do not have symptoms like wheezing or coughing, they sleep better, don't miss work or school, and can take part in physical activities.[1]

Why is asthma a public health priority?

The costs of asthma are unnecessarily high. Uncontrolled asthma results in loss of life, hospitalizations, and significant healthcare costs. Symptoms not severe enough to require a visit to the emergency department (ED) or to a physician can still substantially impair quality of life. Asthma results in many lost nights of sleep, disruption of family and caregiver routines, and restricted activities. Asthma is the leading work-related lung disease; and recent evidence suggests that at least ten percent, and up to 26 percent in some regions, of adult- onset asthma may be work-related.[2,3] Chapter II in this report describes the cost of asthma with regard to death, hospitalization, economic costs, and quality of life.

What are the rates of asthma?

This report generally describes the "prevalence" of asthma, which is the percentage of people who have the condition at a single point in time. This is different from the "incidence" of asthma, which is the rate at which people within a population develop a new case of the condition over a specific period of time (such as one year).

Asthma prevalence has increased significantly over the past three decades. Reasons for this rise in prevalence are unclear and likely related to several factors. Although many triggers of asthma attacks in people with asthma are well recognized, causes of the initial development of asthma among those who did not previously have asthma are poorly understood. Family history of asthma, exposure to viral infections during infancy, environmental factors, and socio-economic factors are all suspected to be involved in the development of asthma.

The reported prevalence of asthma is dependent upon diagnosis of the condition. It is quite possible for people to suffer from asthma without being appropriately diagnosed. For example, one study of children conducted in Seattle found a physician-diagnosed asthma prevalence of 11.5% but the prevalence of wheezing without a diagnosis of asthma was 7.3%, suggesting that the actual asthma prevalence rate may have been nearly 40% higher than reported.[4] Data in this report also suggest that the actual prevalence of asthma may be greater than reported – youth data presented in Chapter IV

also show that more students report asthma symptoms than have been diagnosed with asthma.

What kinds of people have asthma?

Chapter III in this report describes the prevalence of asthma in Washington, both overall and among people of different ages, genders, race/ethnic groups, and different communities. In Chapter IV we identify important risk factors that individual people can avoid to minimize their risk for developing asthma or making their asthma worse. Generally, data are presented separately for youth and adults because data systems collect information separately for youth and adults using telephone and school-based surveys.

What can we do about asthma?

Interventions that may be effective for asthma prevention include minimizing exposures that cause asthma (sometimes called "asthmagens"). The greatest number of people can be reached efficiently by changing policies and systems rather than by educating people one by one. This includes helping policymakers to understand what rules or practices they can change in communities, worksites, schools, and home domains to improve asthma. Chapter V describes the current status of policies and practices in these domains that affect exposure to agents that cause or worsen asthma.

For people who already have asthma we can make sure that they receive the best treatment for and information about their disease. This means that healthcare providers follow "clinical guidelines" for asthma control – recommendations from experts about what medications, advice and education patients should receive. People with asthma can also be educated about making sure their environments are free from exposures that can worsen asthma symptoms or cause an asthma attack (sometimes called "triggers"). In Chapter VI we provide information about clinical services to control asthma and information about the presence of triggers for people with asthma in Washington.

In this section we will use the terms "asthma control" and "asthma management" interchangeably. Recently, the term "control" has become more widely used to emphasize that symptoms from asthma really can be minimized or even eliminated by aggressive clinical and self-care.

What are health disparities?

A "health disparity" occurs when a group of people are unfairly affected by a health condition. Due to systematic failures in disease prevention, diagnosis or treatment, certain populations may have higher risk for developing asthma or effectively controlling their disease. Additional discussion of asthma disparities is included in Chapter VII.

Where do we go from here?

The Centers for Disease Control and Prevention (CDC) has identified "Healthy People 2010" goals to strive for in controlling asthma. These goals are presented throughout this report in gray boxes, and may indicate the extent to which Washington aligns with national benchmarks for asthma and health.

The report conclusion in Chapter VIII indicates that information in this report is being used by a statewide planning group to develop combined strategies for asthma prevention and control in 2005. These strategies will set the direction for health advocates statewide to conduct asthma programs in 2005-2010.

II. The Impact of Asthma

Those concerned about health in Washington State have a large number of important conditions and risk factors to prioritize. Resources for public health are limited and not every public health issue can be addressed. Asthma ranks among those creating the greatest public health burden, and thus should be considered by decision-makers as deserving attention.

The impact of asthma is explained in this chapter in terms of costs. The costs of asthma to the public are quantified in terms of loss of life, hospitalizations, medical care utilization, and dollars. The burden of asthma for individuals and families is described in terms of symptoms that interrupt normal activities and associated decreases in quality of life.

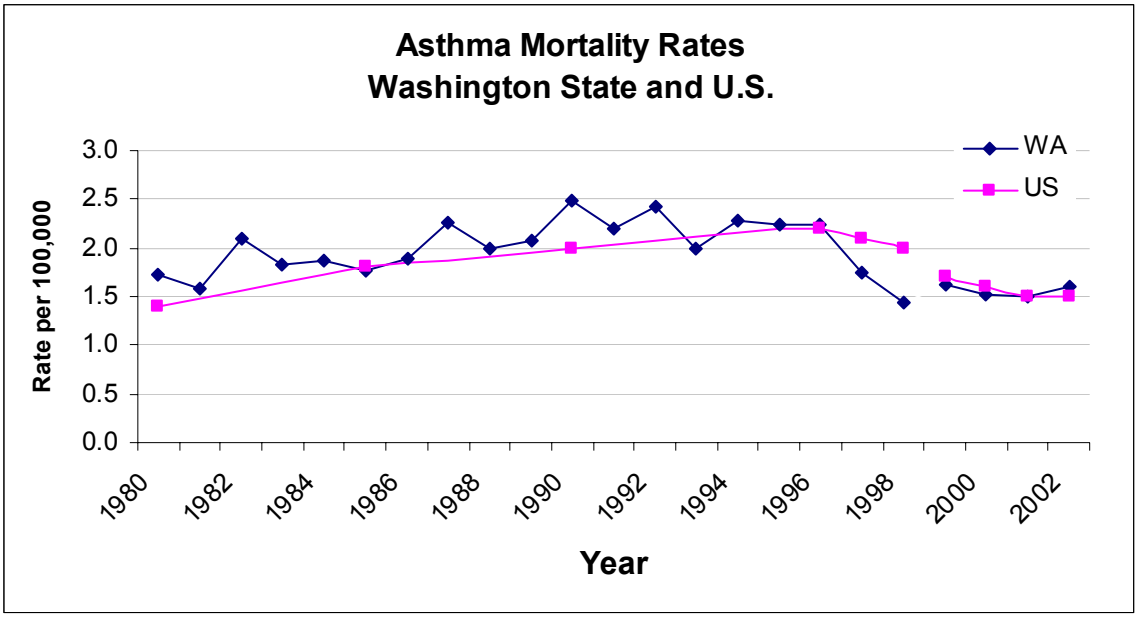
A. Deaths

There were 93 deaths attributed to asthma in Washington in 2002. Washington asthma death rates have been roughly comparable to national rates. Death rates from asthma increased steadily from 1980 until the mid-1990s (see Figure 1). Washington's death rate then declined by about forty percent from 2.5 per 100,000 in 1990 to 1.6 per 100,000 in 2002.[†]

Adults with asthma have also been shown to have greater risk of death due to heart disease and chronic obstructive pulmonary disease (COPD),[5] thus the number of deaths reported here are an underestimate of the true number of deaths in which asthma was a significant contributing factor.

[†] $p<.001$ for decreasing trend in Washington State between 1990-2002

Figure 1: Trends for asthma deaths, WA and US



Source: 1980-2002 National Death Certificates, Washington State Death Certificates. Asthma as primary cause of death. Rates per 100,000, age-adjusted to 2000 US population. Data format changed between 1998 and 1999, indicated on chart by discontinuous line.

Deaths due to asthma among adults have been related to history of clinically severe disease and patients not having appropriate medications. In particular, failure to prescribe inhaled steroids after hospitalization for asthma has been linked to increased risk of asthma death[5] Improvement in medical practices for treating asthma was perhaps spurred by the publication of clinical guidelines in 1991 by the National Institutes of Health (NIH) National Asthma Education Prevention Program (NAEPP)[6] and may explain the national and state decreases in asthma mortality.

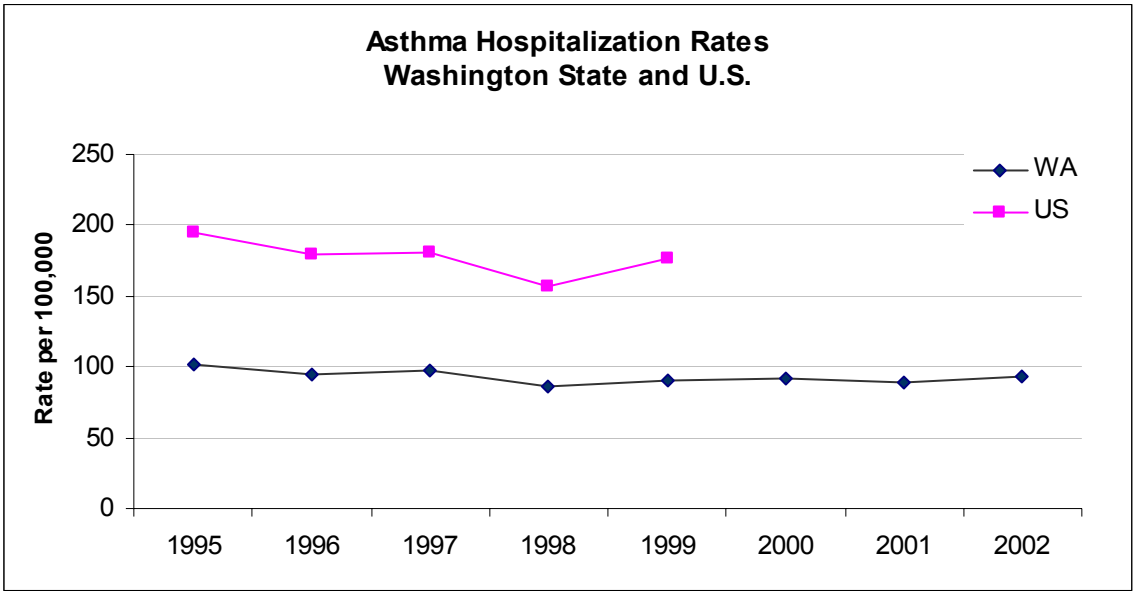
Among children, asthma deaths have been associated with seizures, but more strongly with factors such as poor communication between the child and parents about symptoms, conflict between parents and medical providers (including failure to follow medical directions), and child depression.[7]

B. Hospitalization

In 2002 there were 5,540 hospitalizations for asthma in Washington State, a rate of 93 per 100,000 population. This was nearly half the last known national hospitalization rate of 176 per 100,000 (1999).

Figure 2 shows that Washington State hospitalization trends for asthma have been quite stable since 1995. While the nation has seen a small decline and Washington has not, hospitalization rates have been consistently much lower than national rates.

Figure 2: Trends for asthma hospitalizations, WA and US



Source: National Hospital Discharge Survey, Washington State Comprehensive Hospital Abstract Reporting System (CHARS). Asthma as principal diagnosis, age-adjusted to 2000 US Population.

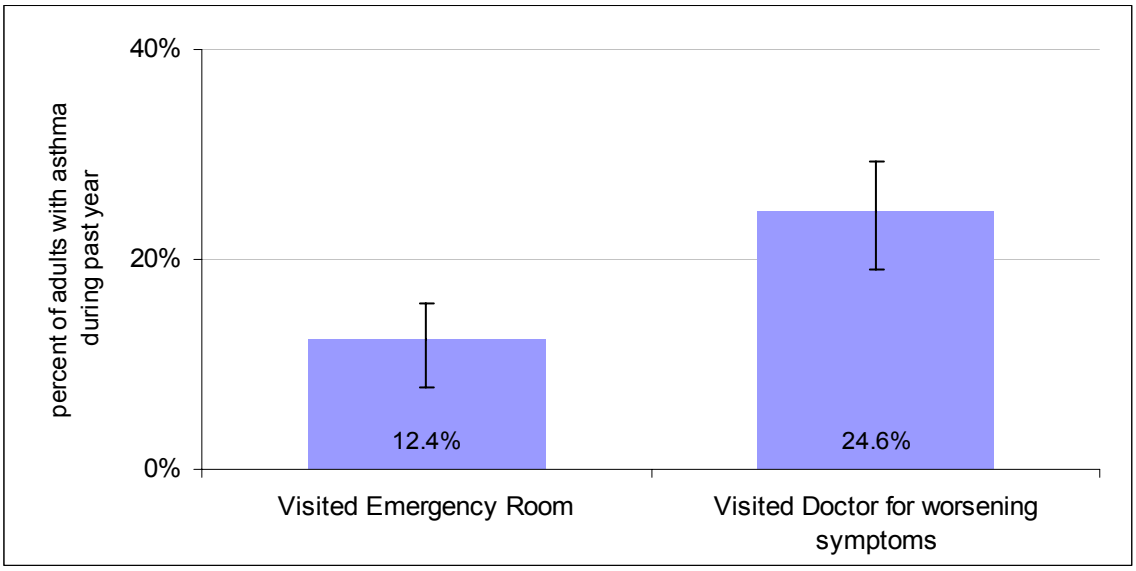
The dissemination and adoption of NAEPP clinical practice guidelines for asthma have likely improved clinical practices, and several studies have noted that preventive practices were related to decreased risk of hospitalization and emergency department visits.[8,9] This may explain some of the national decline in both mortality and hospitalization, through it remains unknown why the national pattern is not reflected in Washington State. Complicating interpretation, the threshold for hospital admissions for asthma may be increasing.[10] In this case, stable (rather than decreasing) hospitalization trends would suggest an increasing prevalence of asthma within the population, as seen in Washington (see Figure 23).

The total number of hospitalizations represents single visits by most people, but multiple visits by a smaller number of people. Hospitalization rates could be substantially reduced if better control of asthma was achieved among the subgroup of people who contribute multiple hospitalizations.

C. Urgent Medical Visits

About 25% of Washington adults with asthma reported that they had to visit a doctor for worsening symptoms during the past year, and 12% had visited an emergency department for acute care related to asthma (see Figure 3). This translates into 100,000 healthcare visits and 48,000 emergency department visits.

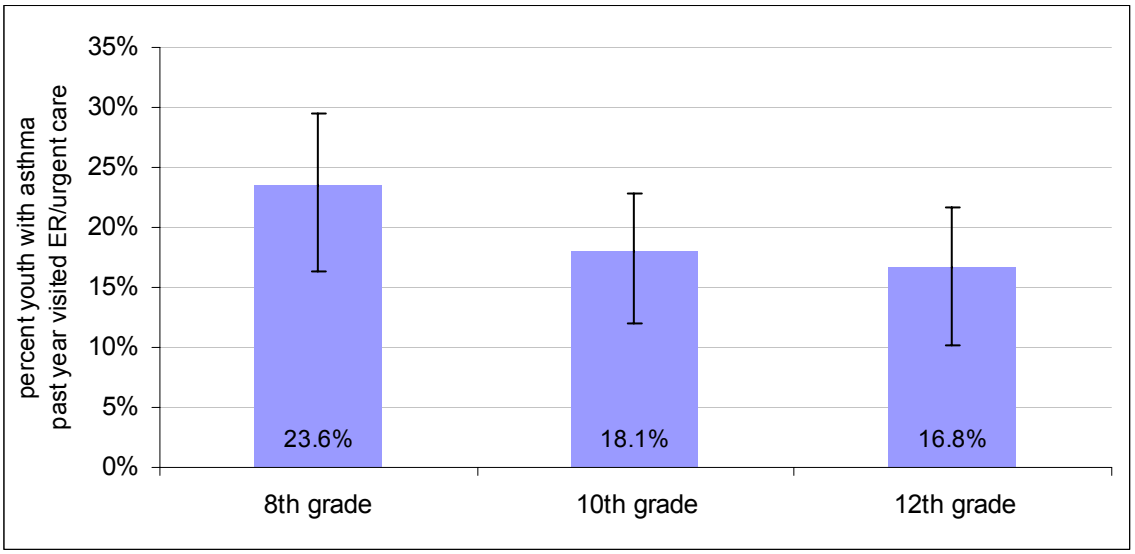
Figure 3: Prevalence of urgent medical visits for asthma during past year, among Washington adults with asthma



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

Young people appear more likely to visit emergency departments for asthma than older people; 8th graders were twice as likely as adults to report emergency room/urgent care visits for asthma during the past year. Nearly one in four eighth grade Washington youth with asthma reported visiting an emergency department or hospital for their asthma during the past year, with the percent of youth making ER visits decreasing with increasing grade (see Figure 4, p=.06).

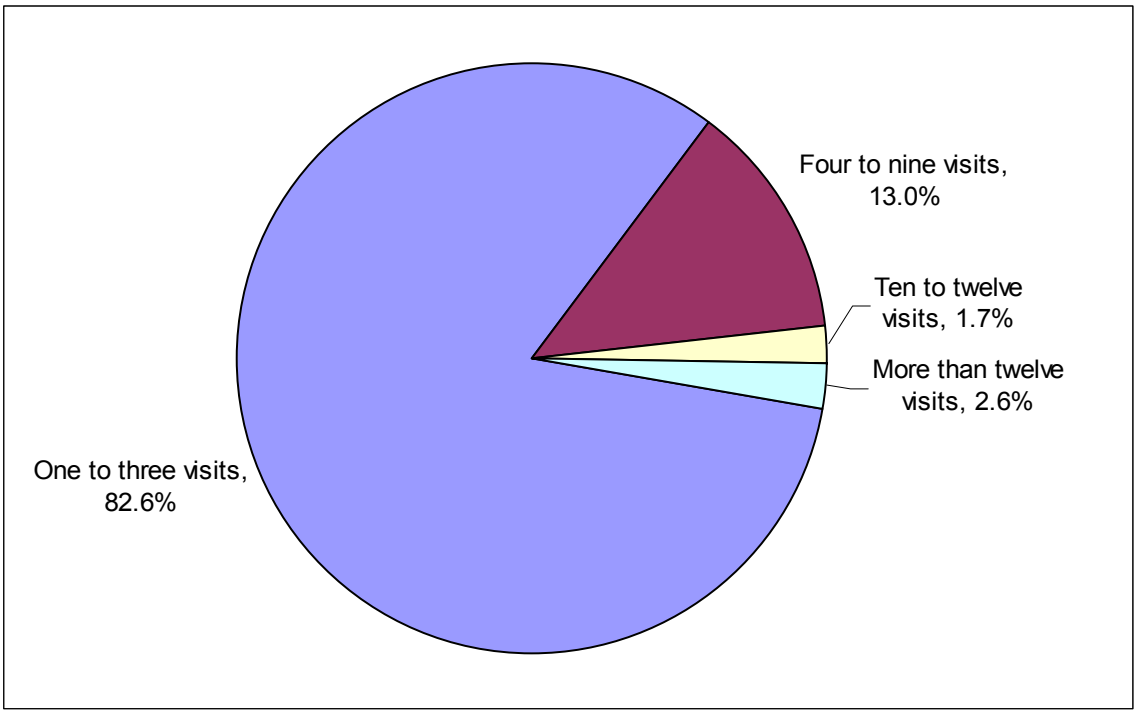
Figure 4: Prevalence of emergency room/urgent care visits during past year, among Washington youth with asthma



Source: 2004 Washington State Healthy Youth Survey (HYS).

Among youth who visited emergency departments during the past year, most (83%) did so only one time, but a small proportion (about 4%) visited emergency departments ten or more times (see Figure 5).

Figure 5: Distribution of emergency room/urgent care visits for asthma during past year, among Washington youth with asthma who visited ER/urgent care facilities



Source: 2004 Washington State Healthy Youth Survey (HYS). Combined 8-10-12th grade estimate

Urgent medical visits create a burden on already stressed medical systems. Healthcare providers must provide emergency care for people with asthma at the expense of attention to other patients. These visits also represent a burden for the individuals and their families or employers who must adjust for the unplanned time and expense of the visits.

D. Economic Costs

Considerable work has been done at the national level to estimate the economic burden of asthma on the healthcare system, and on society as a whole. Based on a review of multiple studies, national experts have concluded[11] that:

- Primary care for asthma is less expensive than hospital care
- Emergency treatment is more expensive than planned treatment
- Nurse-led treatment can be cost-effective
- Families can suffer from the financial burden of treating asthma.

Total Estimated Costs

Methods from previously published studies[12] were used to calculate national and Washington State medical expenditures in 2002 dollars (see Figure 6).

Direct expenditures as a result of asthma include hospital care, physician services, and prescription drugs. Each year, direct costs for asthma in Washington are about $240

million. A large proportion of direct costs are represented by prescription drugs. Previous analyses[13] did not show the same majority of cost attributed to prescription drugs. Changing emphasis on the routine use of controller medications (per NAEPP recommendations) may be responsible for this increase in prescription drug use.

Indirect costs as a result of asthma include school days lost, loss of work, housekeeping,[‡] and mortality. Annual indirect costs as a result of asthma are about $166 million in Washington.

In total, each year, asthma costs Washington more than $400 million. While this is only about one-quarter of the estimated annual $1.5 billion cost of cigarette smoking in Washington,[14] it is still a substantial cost that could potentially be reduced with effective disease management.

Figure 6: Estimated annual economic costs of asthma, Washington State and US

Annual Costs	US 2002	WA 2002
Direct Medical Expenditures		
Hospital care		
Hosp. Inpt. Care	$2,592,000,000	$68,000,000
ED care	$725,700,000	$19,000,000
Hosp outpt. Care	$960,000,000	$25,200,000
Physician services		
Physician inpatient care	$125,900,000	$3,300,000
Physician office visits	$843,300,000	$22,100,000
Prescriptions	$3,901,900,000	$102,300,000
All direct expenditures	$9,148,800,000	$239,900,000
Indirect costs		
School days lost	$1,321,500,000	$34,700,000
Loss of work/Outside Employment		
Men	$495,300,000	$13,000,000
Women	$1,346,400,000	$35,300,000
Housekeeping	$1,004,500,000	$26,300,000
Mortality	$2,164,700,000	$56,800,000
All indirect costs	$6,332,300,000	$166,100,000
Total Costs		
Direct and Indirect Costs	$15,481,200,000	$406,000,000

See technical notes for source of estimates. Estimates are synthetic based on published economic literature. Estimated rounded to nearest $100,000.

Hospitalization Costs

Using Washington State hospitalization billing data (which includes information about direct charges for hospitalization), charges directly assigned to asthma hospitalizations were examined. In 2002 the more than 5,540 hospitalizations with a principal diagnosis of asthma accounted for a total of 16,796 hospital days.

[‡] estimated as value of housekeeper wages among those who indicated they were responsible for caring for the home and family

Each 2002 Washington hospital stay lasted an average of 3 days and were charged an average of $7,000. Better asthma control that reduced the number of hospitalizations could represent significant healthcare savings, in addition to the health benefits for individuals.

Hospitalizations are expensive, and more than half of the hospitalizations are paid for by publicly-funded medical programs. Twenty-one percent of Washington's 2002 asthma hospitalizations were paid for by Medicare, and 34% were paid by Medicaid/Healthy Options.

Workers' Compensation Costs

Costs associated with work-related asthma are documented as part of the Department of Labor and Industries' workers' compensation state fund.[15] From 1995 to 2002, there were 1,099 asthma-related claims paid by state fund dollars. The cost of these claims was $12 million (an average of nearly $11,000 each). Of this, about $1.2 million (an average of $150,000 per year) went to permanent partial disability payments for workers who developed permanent breathing problems. In addition, the fund reimbursed workers for a total of almost 79,000 lost workdays (an average of 10,000 per year). These measures of burden are potentially an underestimate, assuming that not all workers who miss time because of asthma (including asthma resulting from work-related exposure) would file claims for compensation.

E. Symptoms Interfering with Life

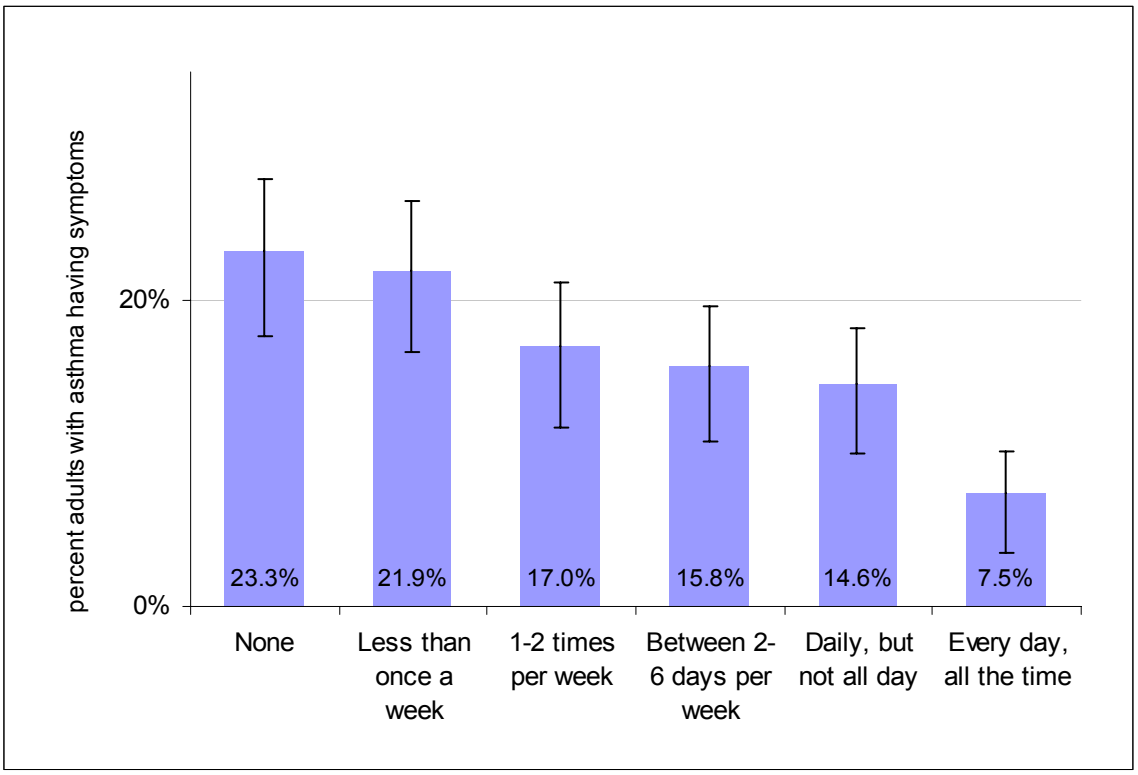
The classic symptom of aggravated asthma is an "asthma attack". During an asthma attack, the insides of airways in the lungs become inflamed and swollen. Muscles around the airways tighten, and less air passes in and out of the lungs. Excess mucus forms in the airways, clogging them even more. The attack can include coughing, chest tightness, wheezing, and trouble breathing. More than half (56%) of adults with asthma in Washington reported that they had an asthma attack during the previous year.

Asthma symptoms create an immediate stress or burden to the affected individual, and they also create a more indirect burden by interfering with normal activities. Entire families are affected when a child has asthma. Parents must take time, including from work, to care for their children, provide oversight of medications, work to limit exposure to triggers in the home, and take them to medical visits. All of these activities can place considerable emotional and financial strain on the family.

Symptom frequency

Symptoms of asthma can be present without an asthma attack. Symptoms of asthma include cough, wheezing, shortness of breath, chest tightness and phlegm production when a person does not have a cold or respiratory infection. About 76% of adults with asthma reported having symptoms on one or more days during the past month; one in five reported having symptoms every day (see Figure 7).

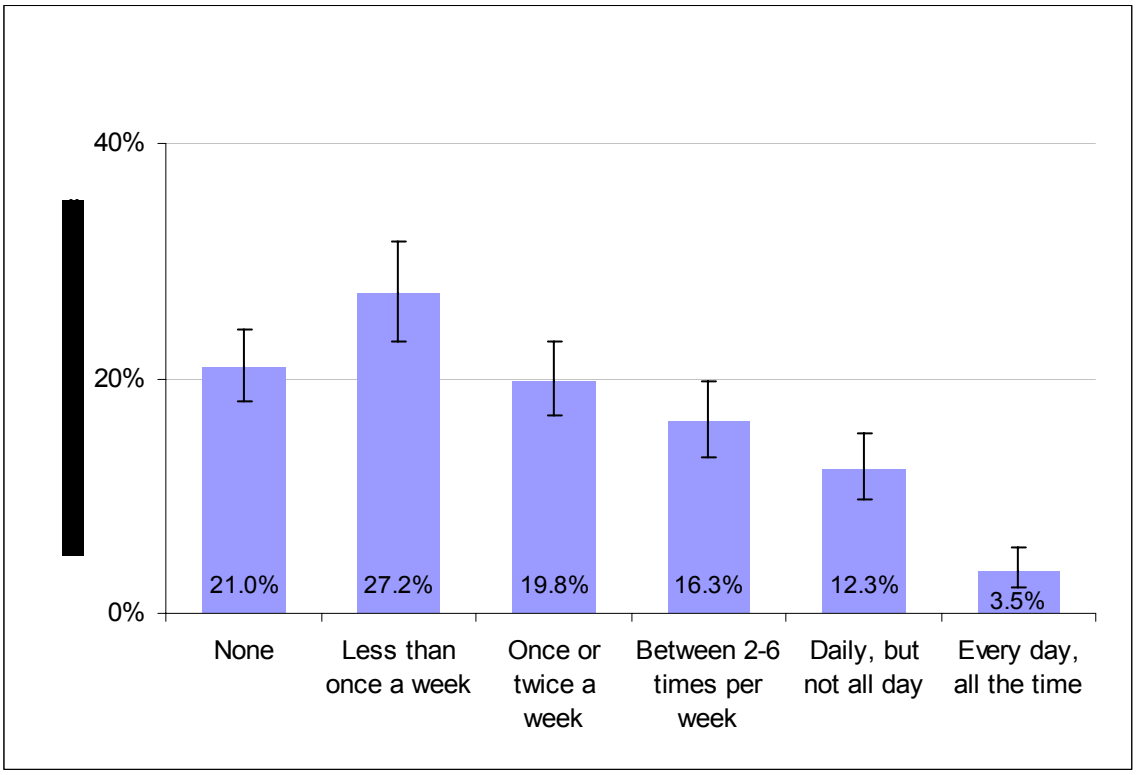
Figure 7: Distribution of asthma symptom frequency in past month, among Washington adults with asthma



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

One in seven youth with asthma experiences symptoms every day (see Figure 8). Fewer youth with asthma than adults with asthma report experiencing daily symptoms, although the difference is small.

Figure 8: Distribution of asthma symptom frequency in past month, among Washington youth with asthma



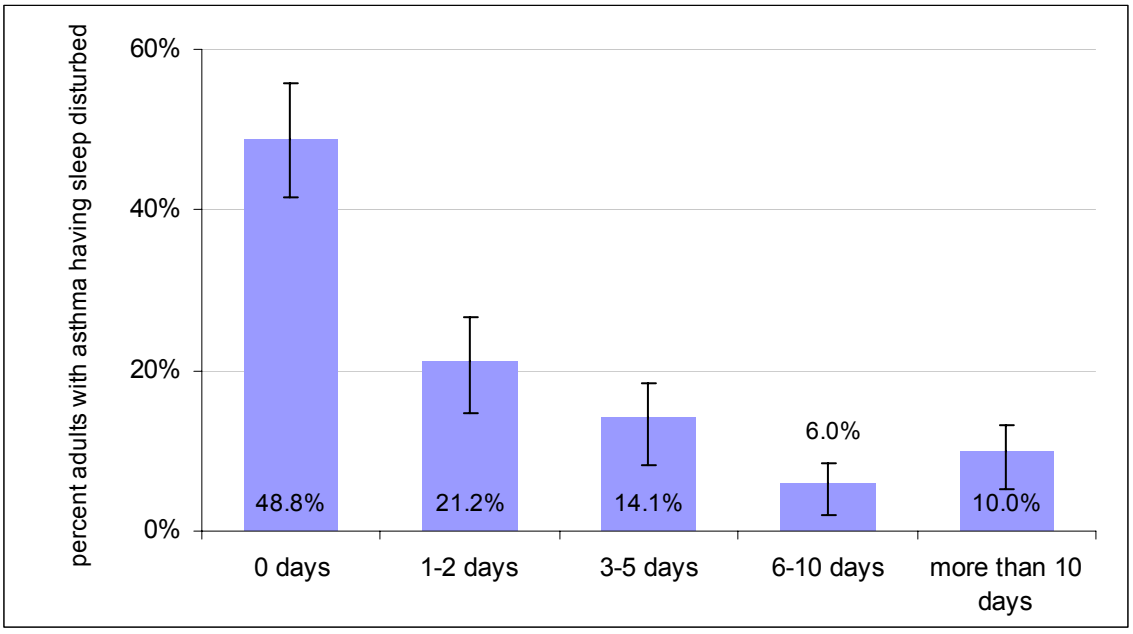
Source: 2004 Washington State Healthy Youth Survey (HYS), grades 8-10-12 combined

Sleep Disruption

People with asthma may have disturbed sleep due to their asthma symptoms. Loss of sleep can result in poor mental and physical functioning.

About half of Washington adults with asthma reported that they had lost sleep during the past month due to asthma symptoms (see Figure 9). One in ten had sleep disturbance more than ten days in the past month.

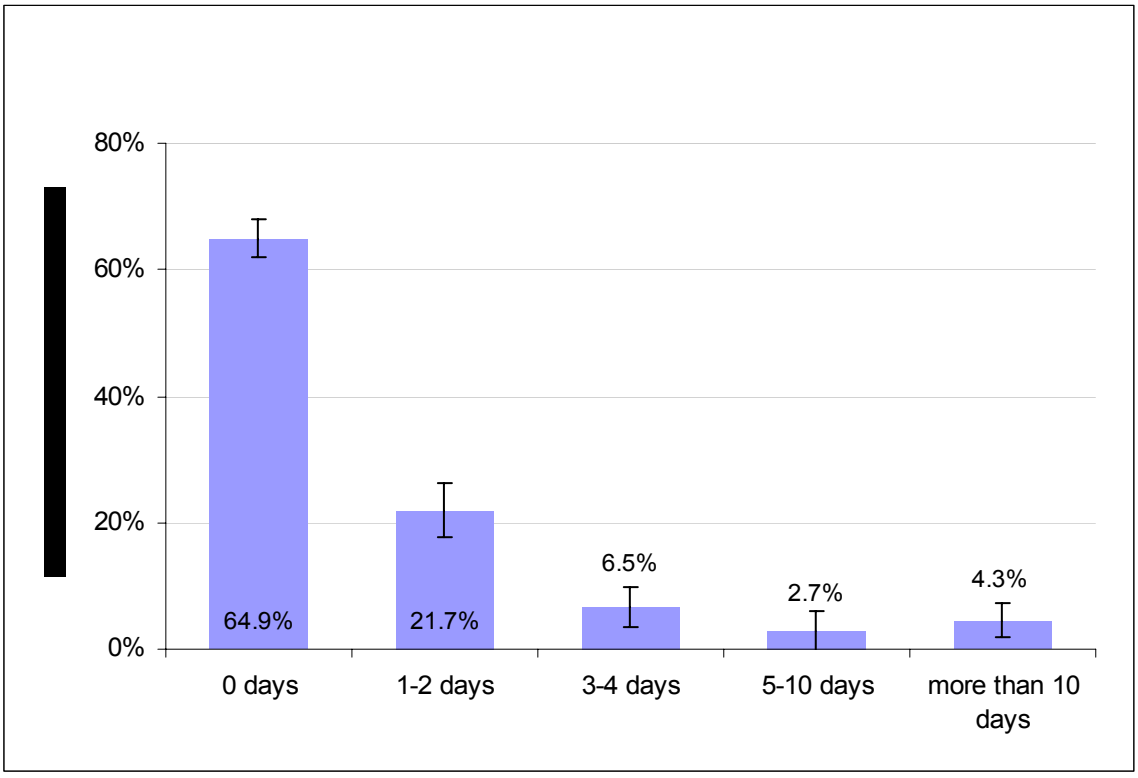
Figure 9: Distribution of asthma-related sleep disturbance frequency in past month, among Washington adults with asthma



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

In comparison to Washington adults, youth were less likely to report any sleep disturbance from asthma. About two-thirds of youth did not report sleep disturbance, but about ten percent had disturbance at least weekly (see figure 10).

Figure 10: Distribution of asthma-related sleep disturbance frequency in past month, among Washington youth with asthma

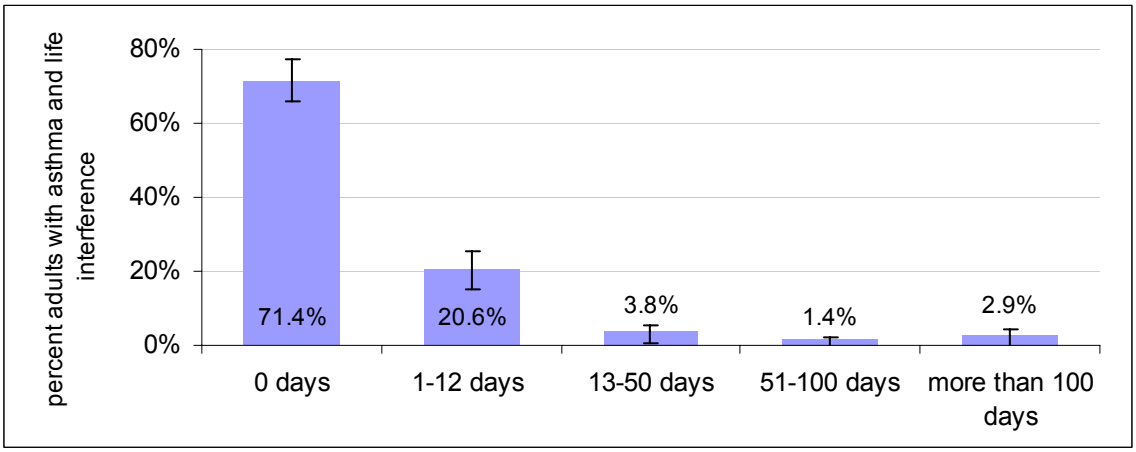


Source: 2004 Washington State Healthy Youth Survey (HYS), grades 8-10-12 combined

Interference with Usual Activities

As a result of serious asthma attacks, or due to other acute symptoms, people with asthma may sometimes not be able to do their usual activities. Just under one-third of Washington adults with asthma reported that they could not do their usual activities at least one day during the previous year because of their asthma. The majority of those with any days of limited activities were affected for twelve or fewer days (see Figure 11).

Figure 11: Distribution of days adults could not do usual activities because of asthma during previous year, among Washington adults with asthma



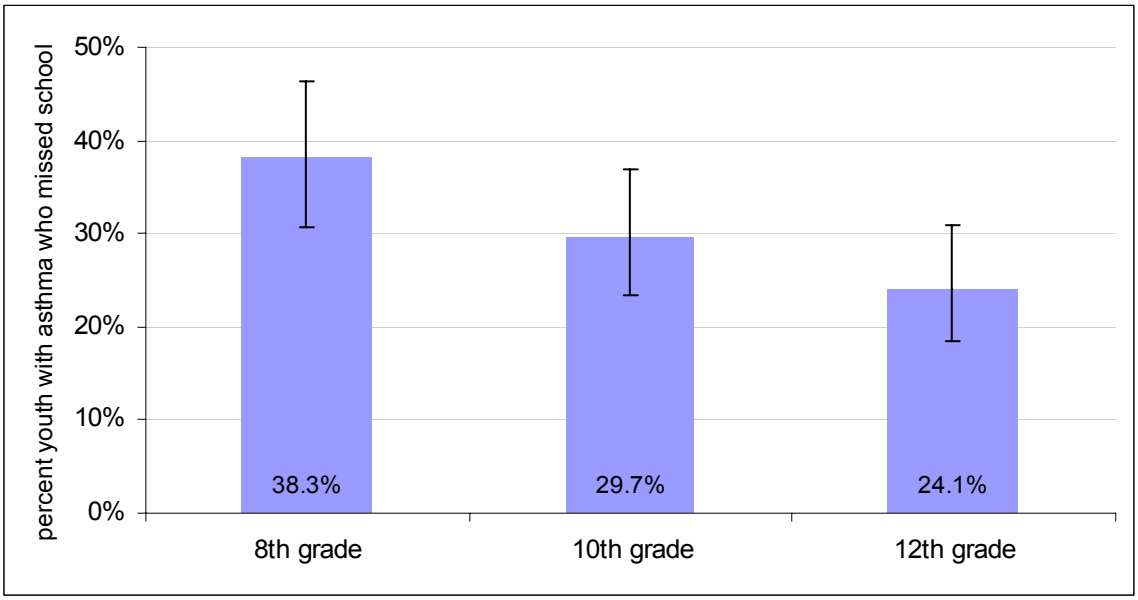
Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

More than one-third of 8th graders with asthma reported missing at least one day of school in the previous year due to their asthma. Reported asthma-related absenteeism progressively decreased for high school students in comparison to 8th graders.[§] Among 12th graders with asthma about one in four reported missing at least one day of school due to asthma during the previous year (see Figure 12). Youth with more severe asthma reported missing school more than youth with less severe asthma.[**]

[§] Odds for any school absences vs. no absences by asthma status after adjusting for asthma symptom severity were 0.86. Reported asthma-related absenteeism progressively decreased with increasing grade (p=.006 for trend, see figure 50 for symptom severity distribution)

[**] Odds for any school absences vs. no absences by asthma status after adjusting for grade were 2.3. Reported asthma-related absenteeism progressively increased with increasing asthma symptom severity (p<.001 for trend, see figure 50 for symptom severity distribution)

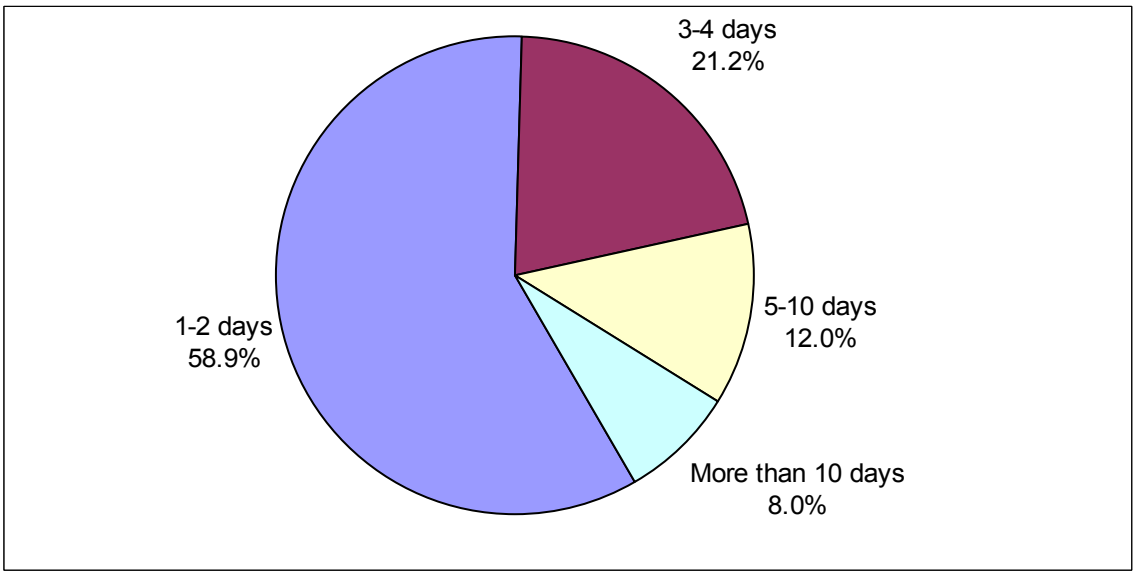
Figure 12: Percent of youth who missed school because of asthma during previous year, among Washington youth with asthma



Source: 2004 Washington State Healthy Youth Survey (HYS), among youth with current asthma.

Among youth who had missed any school during the previous year due to their asthma, most (59%) only missed one or two days, but 20% missed a week of school or more (see Figure 13). Loss of school time may contribute to poor academic performance and social development.

Figure 13: Distribution of days Washington youth missed school during the previous year because of asthma, among youth with asthma who missed any school days



Source: 2004 Washington State Healthy Youth Survey (HYS), grades 8-10-12 combined

National Objectives

Washington has not met Healthy People 2010 goals for reducing activity limitations among people with asthma to ten percent or less. In Washington, 29% of adults had one or more days of activity limitation during the previous year, and 24-38% of youth missed one or more days of school during the previous year. Healthy People 2010 objectives have not yet been established to specifically measure lost school or work days (see box).

Healthy People 2010 Objective 24-4
Reduce activity limitations among people with asthma.

Target:

- 10% or fewer people with asthma will experience activity limitations because of their asthma

* age-adjusted to year 2000 standard population

Healthy People 2010 Objective 24-5
Reduce the number of school or work days missed by people with asthma because of their asthma

(Targets not established)

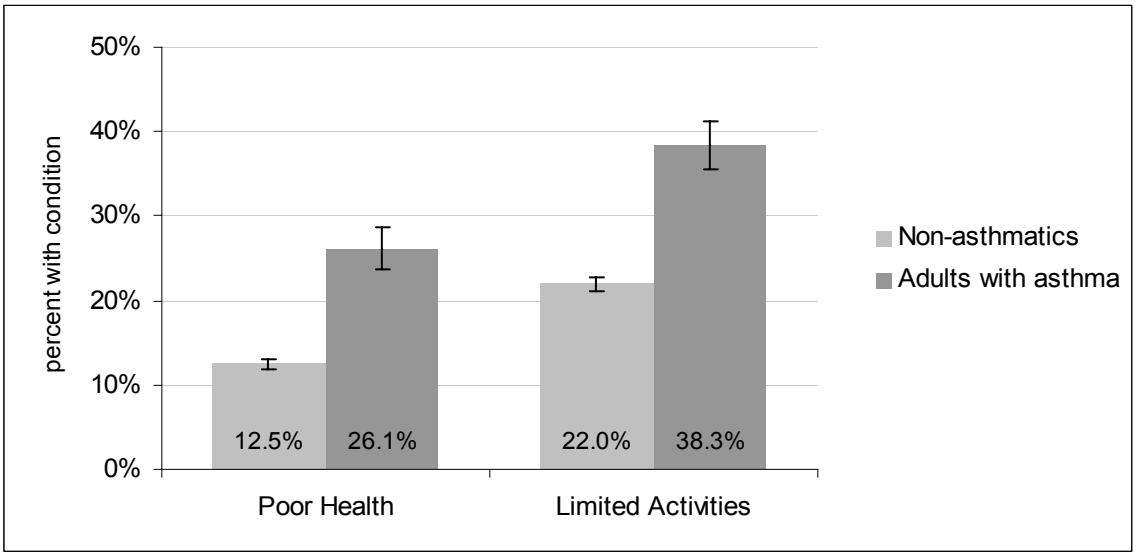
F. Quality of Life

Constant struggle with asthma symptoms and resultant disturbance of activities can contribute to decreases in overall quality of life.

General Health Status

In Washington, adults with asthma were twice as likely as adults without asthma to rate their health status as "fair" to "poor" (see Figure 14). Additionally, more than one-third of people with asthma, significantly more than people without asthma, reported that their activities were limited because of their health.

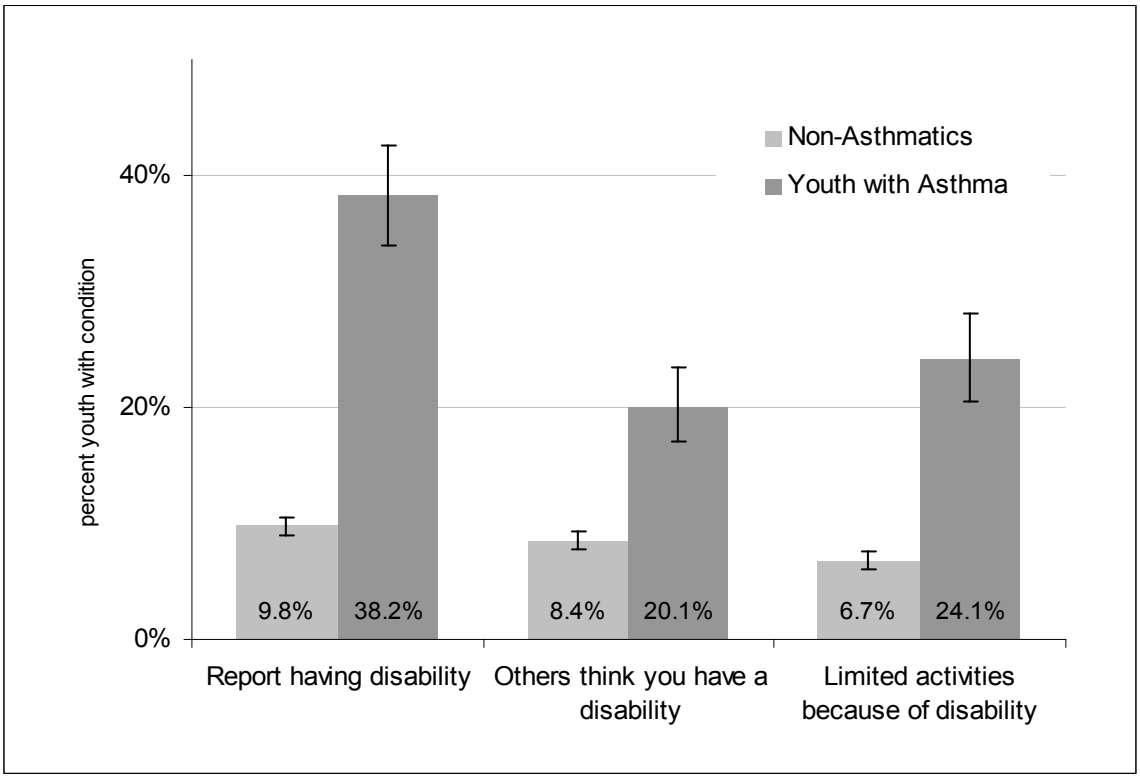
Figure 14: Prevalence of poor health/limited activities by asthma status, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Similar to adults, youth with asthma were more likely to report poor health than youth without asthma. For example, 10th grade youth with asthma were four times as likely as youth without asthma to report having a long-term disability or long-term health problem. One in five youth with asthma reported that they believe other people would consider them to have a disability, and one in four (four times as many as youth without asthma) said that they had to limit their activities because of a disability or long-term health condition (see Figure 15).

Figure 15: Prevalence of disability and limited activities by asthma status, among Washington youth (10th grade)



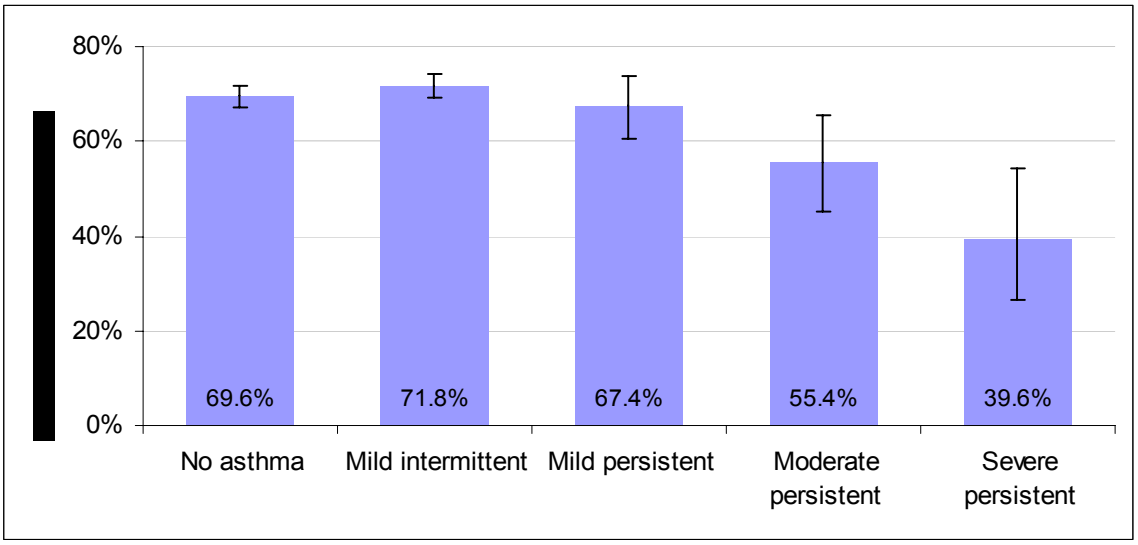
Source: 2002 and 2004 combined Washington State Healthy Youth Survey (HYS).

Academic Achievement

Loss of school days due to asthma symptoms may result in decreased academic performance. Examination of differences in academic achievement for youth with and without asthma did not reveal any differences; however, differences were observed after stratifying by asthma severity (see discussion in Chapter VI for description of asthma symptom severity). Young people with mild intermittent or mild persistent asthma were as likely as youth without asthma to report high academic performance (getting mostly "As" and "Bs" in school); however, youth with moderate persistent and severe persistent asthma had decreased academic performance (see Figure 16). The odds for high academic performance among youth with severe persistent asthma were only 60% in comparison to youth with no asthma or mild asthma. The odds for high academic achievement among youth with moderate persistent asthma were 80% in comparison to youth with no asthma or mild asthma.[††]

[††] The odds for high academic achievement (mostly As and Bs) vs. other grades (mostly Cs, Ds, Fs) by asthma status after adjustment for grade and gender were 0.65 (95% CI: 0.60-0.71). The proportion of youth with high academic achievement decreases with increasing asthma severity (p<.001 for trend). Only 10th grade shown in Figure 15.

Figure 16: Prevalence of high academic performance by asthma status and symptom severity, among Washington youth (10th grade)

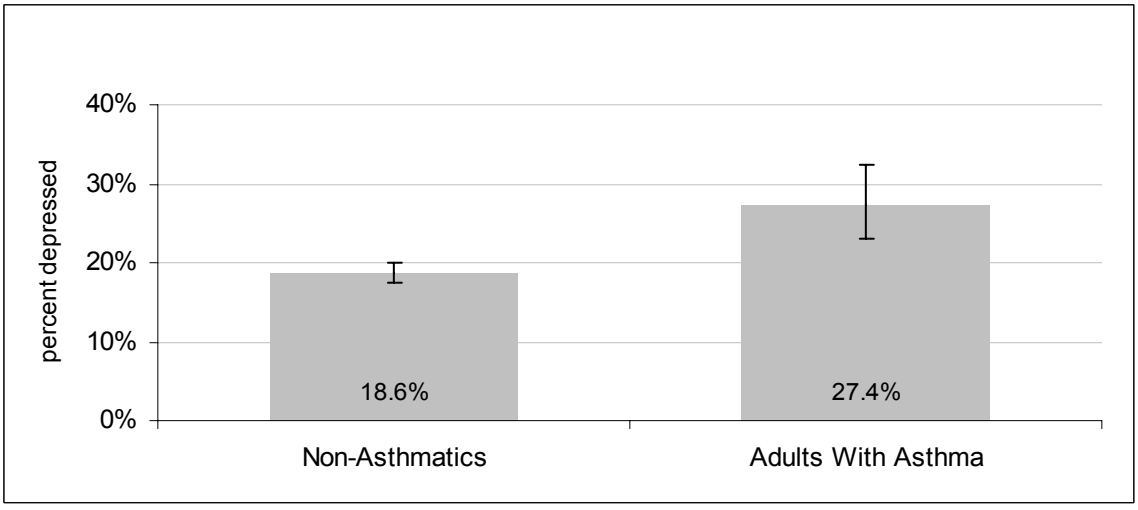


Source: 2002 and 2004 combined Washington State Healthy Youth Survey (HYS).

Mental Health

The effect of asthma on quality of life is not just limited to physical health and activity levels, it can also include mental health. Among adults, about one in four people with asthma reported depression – significantly more than adults without asthma (see Figure 17).

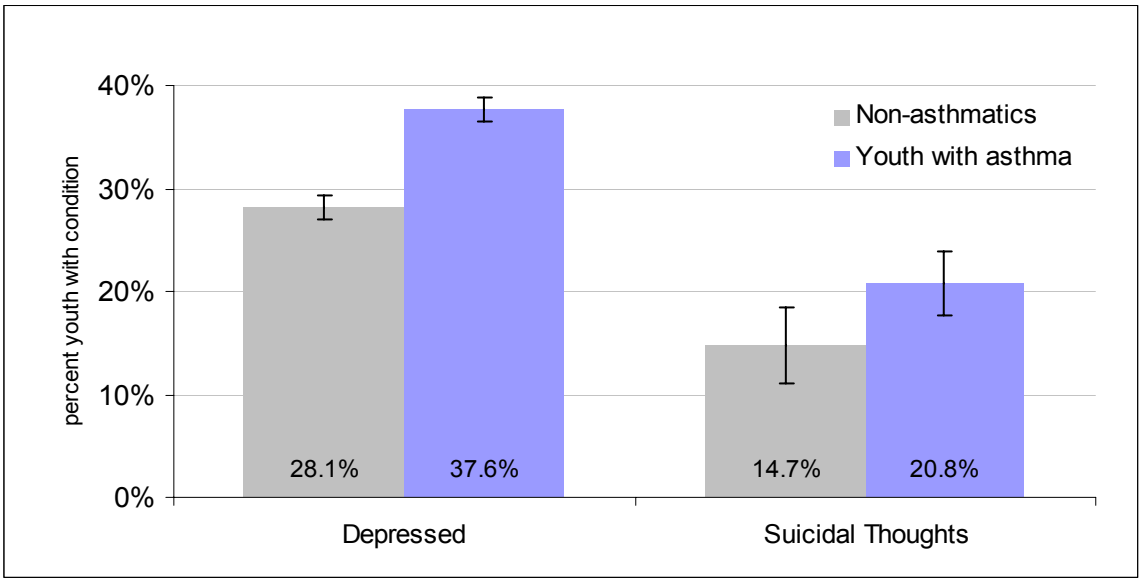
Figure 17: Prevalence of depression by asthma status, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Even more disturbing, youth with asthma were significantly more likely than youth without asthma to report depression and suicide ideation.‡‡ Among youth with asthma, 38% reported being depressed and 21% reported "seriously thinking" about suicide during the previous year (see Figure 18).

Figure 18: Prevalence of depression and suicidal thoughts by asthma status, among Washington youth



Source: 2002 and 2004 HYS combined, grade standardized for equal distributions of 8th-10th-12th respondents.

‡‡ Odds for depression 1.5 (p<.001) associated with having current asthma in comparison to not having asthma, after adjustment for grade and gender; Odds for "seriously thinking" about suicide 1.5 (p<.001) associated with having current asthma in comparison to not having asthma, after adjustment for grade and gender

III. Lifetime and Current Asthma Prevalence

Asthma is one of the most common chronic diseases in adults, and the most common chronic disease in children. About ten million Americans have asthma,[16] including at least 5 million children under age 18.[17,18]

Although about 87% of Washington adults have never personally had asthma, a recent national survey suggests that 35% of the population without asthma has at least one household or immediate family member with asthma.[19] Because good asthma control includes changes in home environments and poor asthma control can substantially affect families in terms of lost time at work or school and healthcare costs, people with household or immediate family members that have asthma are affected by the disease. Therefore, we can say that about half the people in Washington are affected by asthma.

A. Definitions

Information about asthma among adults is collected using Washington's Behavioral Risk Factor Surveillance System (BRFSS), a telephone survey of randomly selected non-institutionalized adults.

The prevalence of asthma among youth is assessed using two methods: youth self-report, as part of the school-based Washington State Healthy Youth Survey (HYS) questionnaire; and proxy reports by parents, collected as part of the BRFSS telephone survey when there are children living in the household.

Both adults and youth are classified in Washington's public health surveys as having "lifetime asthma" (that is, having had asthma during their lifetime) if they report that a doctor has at some time told them they have asthma. This is consistent with national definitions for lifetime asthma.

An adult is classified as having "current" asthma if they report having ever been told by a healthcare professional that they have asthma and also respond "yes" when subsequently asked if they still have asthma.

Unlike adult surveys, which are conducted by telephone, and where adults who report never being told they had asthma by a doctor are "skipped out" from further questions about asthma (including for proxy reports about youth asthma), youth who take Washington's self-administered HYS questionnaire have the opportunity to answer questions about taking asthma medications or having asthma attacks even if they have never been diagnosed by a doctor. Data presented later in this chapter indicate that more youth report having asthma attacks or taking medication than have ever been told they have asthma by a doctor. This inconsistency could be the result of youth not understanding the question or misunderstanding about what is meant by an "asthma attack" or "asthma medications". It could also be the result of real asthma among youth that is undiagnosed by a doctor.

With the assumption that most of the reporting inconsistency was related to inaccurate over-reporting of past-year medication or asthma attack, a two-stage definition for current asthma among youth was applied that required having been told by a doctor and having at least one attack or taking asthma medications during the previous year. This approach is consistent with the definition used for adults (who are asked "do you still have asthma?" which would logically be conditional upon either still having symptoms or taking treatment for asthma). In fact this method brought estimates for oldest youth to similar levels as adults.

Presentation of "current asthma" among youth for the remainder of this report uses the two-stage definition just described.

B. Asthma Onset

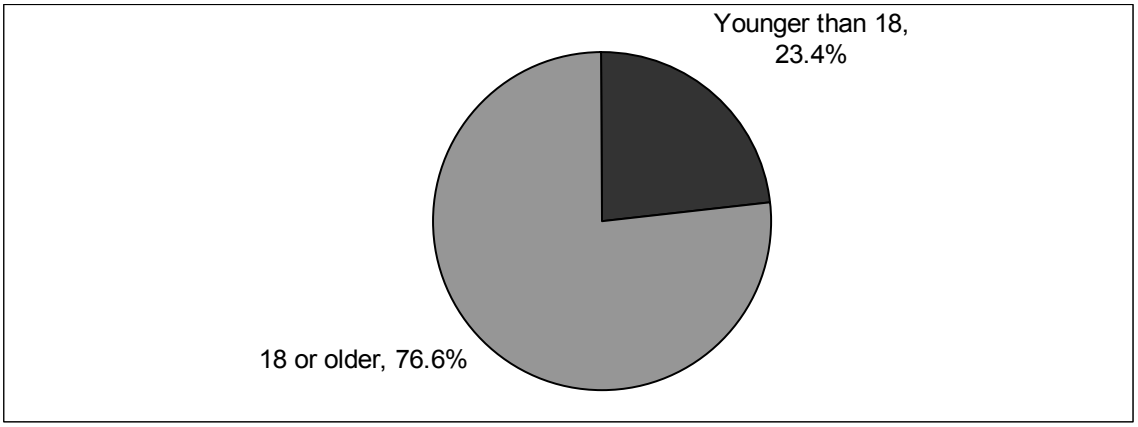
Asthma onset can occur anytime in life. Asthma among youth often begins in early childhood; more than 50% of children with persistent asthma develop symptoms prior to 3 years of age, and 80% develop symptoms prior to age 6.[20]

An estimated 30 to 50 percent of children with asthma (particularly males) appear to "outgrow" asthma at puberty, but often asthma may reappear in later life. Although these children may be asymptomatic (potentially classified as "lifetime" but not "current" asthma), their lung function may be permanently affected. Between 5 and 10 percent of children with asthma that is not considered serious progress to having severe asthma in later life.[11]

Among adults who have ever been diagnosed with asthma, only one in four reported being first diagnosed with asthma during childhood (see Figure 19), indicating that onset of new asthma during adulthood is substantial. It is possible that some Washington adults were in fact diagnosed with asthma during early childhood (or had undiagnosed asthma in childhood) but "outgrew" the condition and that these same people over time may not recall having had the condition or even conclude that they never really had it.

New-onset asthma in adults with airway obstruction and a history of smoking must be differentiated from chronic obstructive pulmonary disease (COPD). COPD includes emphysema and chronic bronchitis, which are airway obstructions due to lung damage typically associated with smoking.

Figure 19: Age at diagnosis of asthma, among Washington adults



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

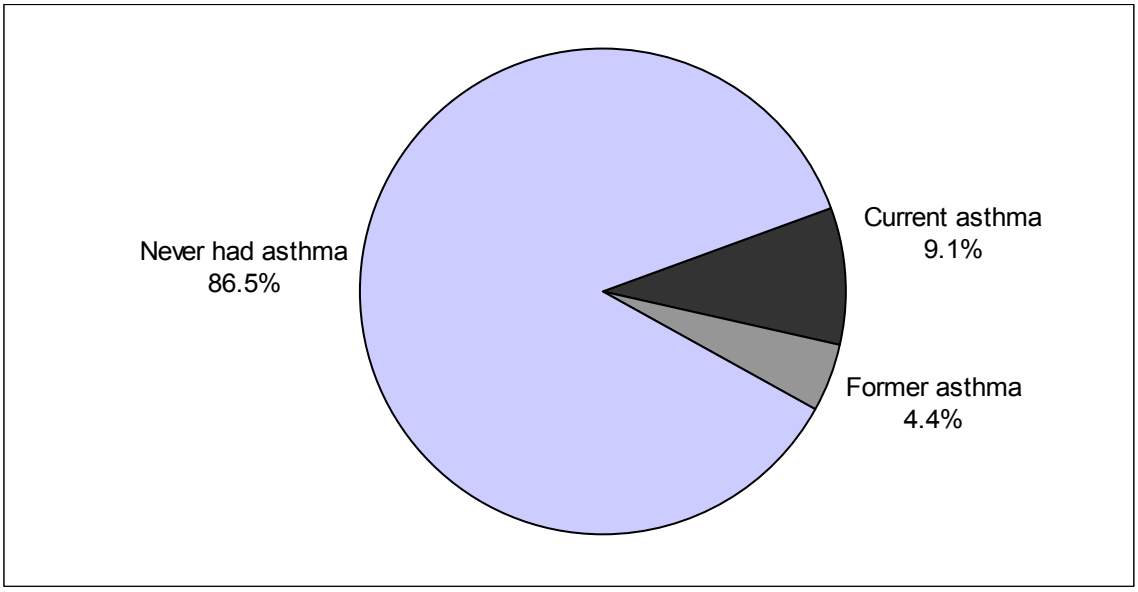
Both lifetime and current asthma prevalence may be useful measures for understanding the burden of asthma among adults and youth, although current prevalence demands the most attention in either group.

C. Adult Prevalence

More than one in ten Washington adults (13.5%) has been told by a health professional at some point during their lifetime that they have asthma. Nationally, 11% of adults had ever been told they had asthma. [21]

About two-thirds of Washington adults who have had asthma during their lifetime report still having asthma (see Figure 20). The prevalence of current asthma among adults in Washington was 9.1% in 2003. This translates into nearly 400,000 Washington adults with asthma (see table in appendix D for state and county-level estimates).

Figure 20: Prevalence of lifetime and current asthma among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

D. Youth Prevalence

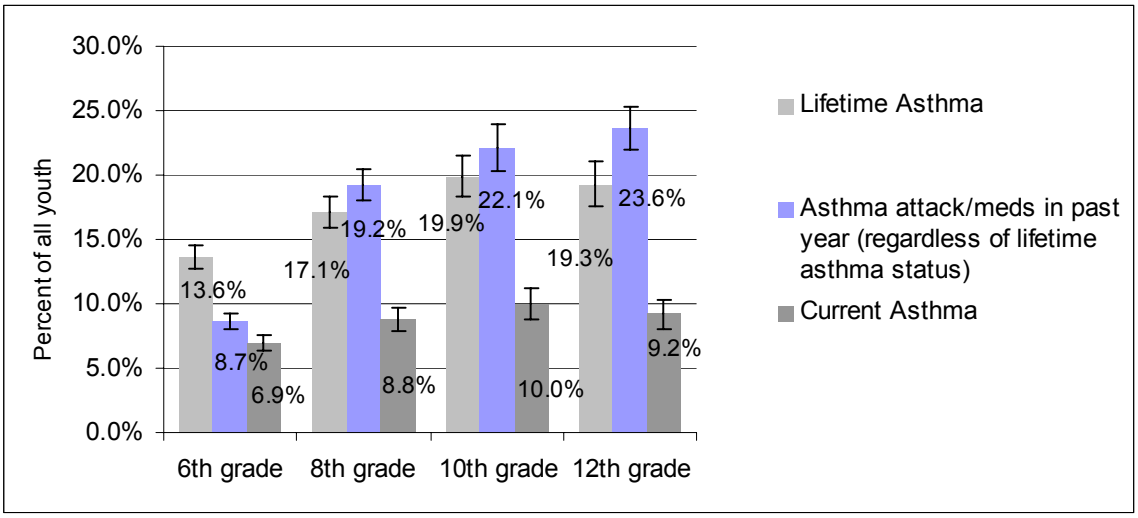
Youth self-report

Older youth were more likely than younger youth to report having been told by a doctor they have asthma (lifetime asthma). Just over one in ten sixth graders and about one in five high school students reported lifetime asthma.

About half of those youth who said they had ever been told by a doctor they have asthma also reported that they still take medication or had an asthma attack during the previous year, which is consistent with adult patterns and adult proxy reports. However, about one in ten youth who had never been told by a doctor they have asthma also reported that they did take asthma medication or had an asthma attack during the previous year. This explains the greater prevalence of reported previous year asthma medications/attacks for 8th, 10th and 12th graders in comparison to lifetime asthma (see Figure 21).

About 9-10% of 8th, 10th, and 12th graders reported currently having asthma, and 7% of 6th graders were classified as currently having asthma, based on both having been at some time diagnosed by a doctor and having asthma symptoms or treatment during the past year (see Figure 21).

Figure 21: Prevalence of lifetime and current Asthma by grade, among Washington youth (youth self-reported)



Source: 2004 Washington State Healthy Youth Survey (HYS)

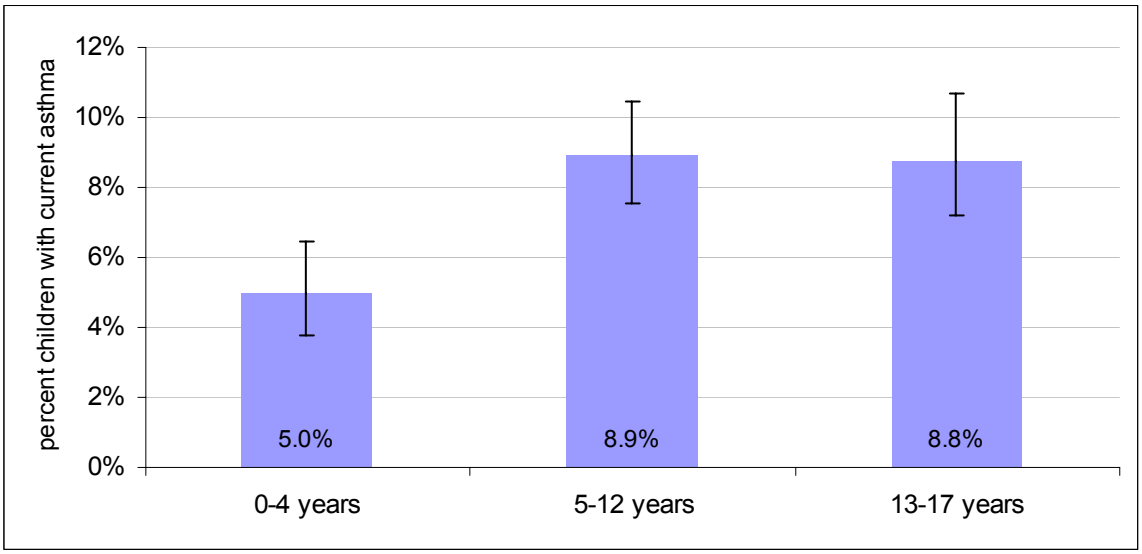
Parent/adult proxy reports of childhood asthma

About 17% of Washington adults who live in households with children indicated that at least one child had been diagnosed with asthma during his/her lifetime. This suggests that one in five families has one or more children affected by asthma.

Parent/adult proxy reports about current asthma among children are similar to those from the HYS using that two-stage definition described previously. Parents reported about 9% prevalence of current asthma for both 5-12 year olds and 13-17 year olds, respectively, and about 5% prevalence for children younger than five.

Using an average value of 8% current asthma for all youth ages 0-17 (calculated from the age-group specific prevalence estimates from parents), we can estimate that more than 120,000 children in Washington currently have asthma (see Appendix D for population estimates and county-level estimates). This combined estimate for youth in Washington is similar to national prevalence estimates of 8-9%.[19,22]

Figure 22: Prevalence of current asthma among Washington children and youth (parent/adult proxy-reported)



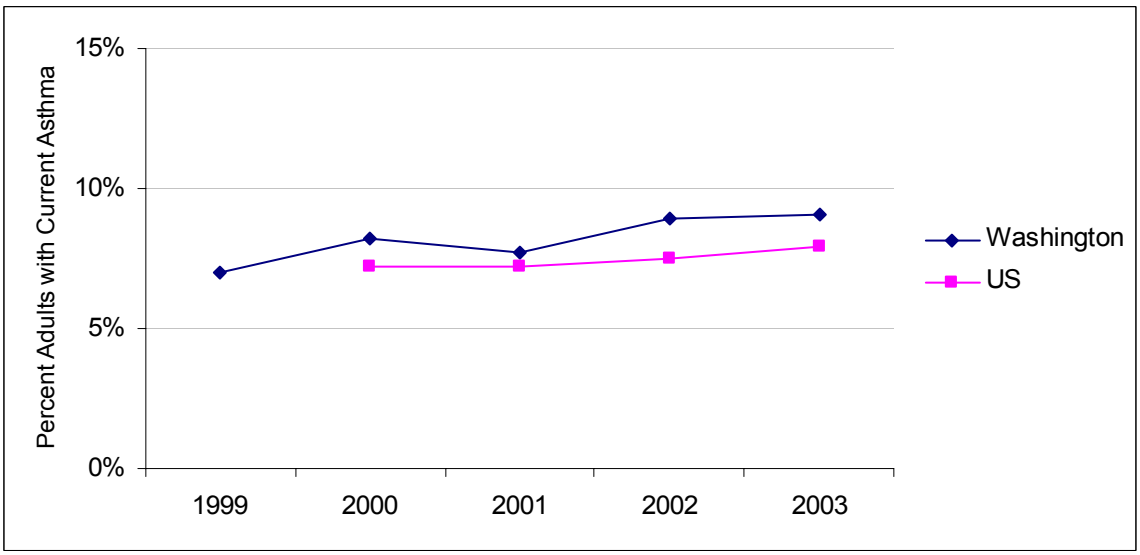
Source: 1999 and 2000 combined Behavioral Risk Factor Surveillance System, parent (proxy) reports for child asthma prevalence

E. Trends in Current Asthma Prevalence

Adults

Washington's prevalence of current asthma among adults is greater than the national prevalence (see Figure 23) and has been reported as one of the highest in the nation.[23] The prevalence of asthma has increased ($p<.05$) by about 30% among Washington adults in recent years, from 7.0% in 1999 to 9.1% in 2003.

Figure 23: Trends for current asthma among Washington State and US adults

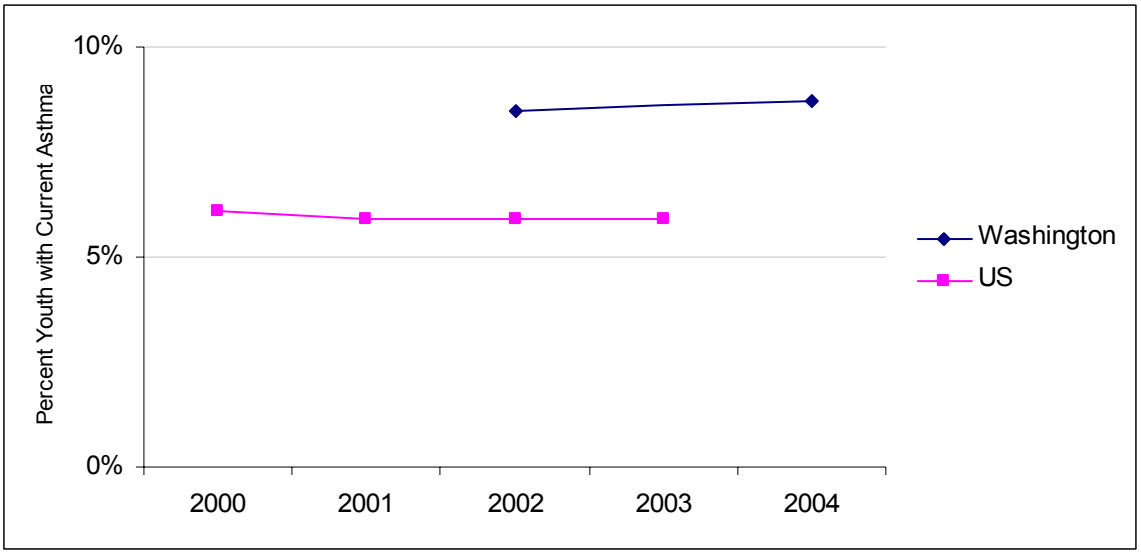


Source: 1999-2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS), National BRFSS median

Youth self-report

As seen among adults, Washington's youth have a higher prevalence of asthma in comparison to the nation. For our most recent year of data (2004), 8.7% of Washington middle and high-school youth (grade-standardized estimate for 6th, 8th, 10th, and 12th combined) had current asthma in comparison to the most recent national estimate (2003) of 5.9% for 12-17 year olds (see Figure 24). Washington's asthma prevalence change from 8.5% to 8.7% prevalence was not significant.

Figure 24: Trends for current asthma among Washington State and US youth

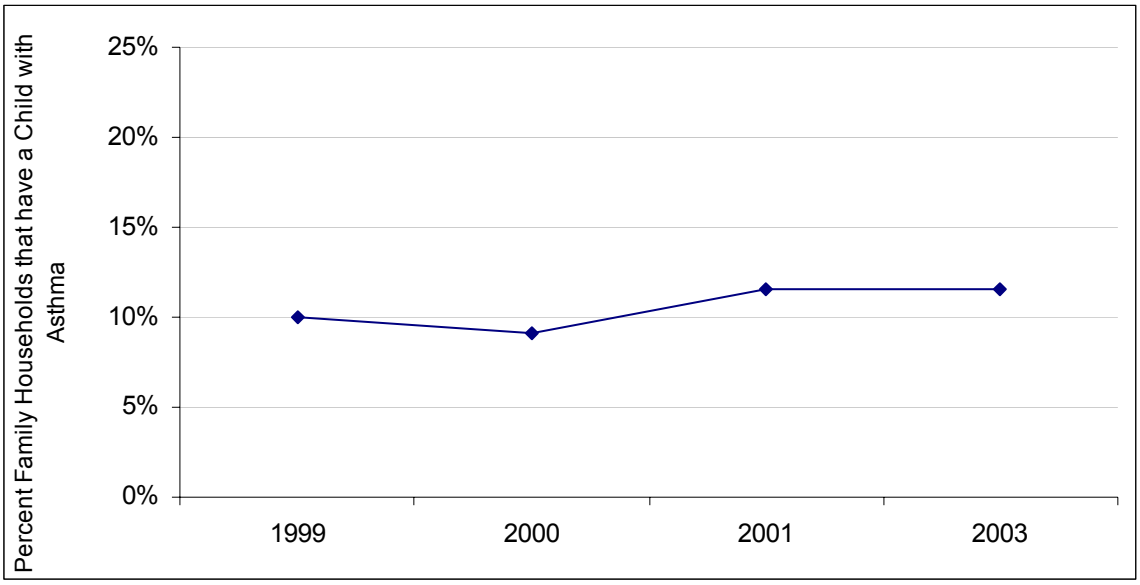


Source: 2002 and 2004 Washington State Healthy Youth Survey, grade-standardized estimate for 6th-12th grades combined; 2000-2003 National Health Interview Survey, youth aged 12-17 combined.

Parent/adult proxy reports

In 2003, about 11.5% of adults in households with children reported that at least one child currently has asthma, which was a fifteen percent proportional increase from 10.0% in 1999 (see Figure 25, $p<.05$).

Figure 25: Trend for Washington households with children who have current asthma, among households with children



Source: 1999, 2000, 2001, 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

IV. People Affected by Asthma in Washington

The prevalence of asthma is different among population subgroups in Washington. These differences are important to understand when planning programs, to assure that messages, campaigns, or policies reach the right people. When available, information about hospitalization and death rates is included for subgroups. When patterns of hospitalization or death are evident that cannot be explained by prevalence patterns, this may suggest need for targeted asthma control interventions.

The previous chapter described Washington asthma prevalence for broad age groups (adults and youth in general), and this chapter provides more refined descriptions of asthma by specific age groups in addition to gender and other key demographic groups.

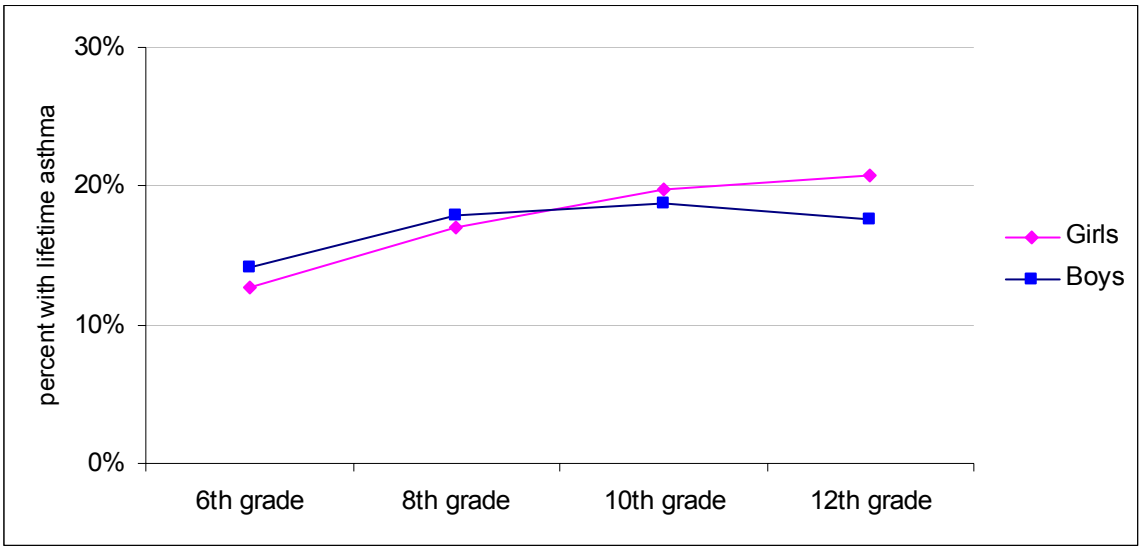
A. Age and Gender

Youth Lifetime and Current Prevalence

Gender-specific prevalence estimates in Washington for young children (younger than grade six) are not currently available; however national data indicate that boys are more likely to have asthma than girls at these ages.[24] The overall prevalence among children younger than five was 5% compared to 9% among school-aged children (see Figure 21), suggesting that asthma is least prevalent among the youngest children. Alternatively, due to the difficulties in accurately diagnosing asthma in young children, many practitioners may hesitate to "label" a patient with asthma without long-term history of symptoms, hence leading to an underestimate of true asthma prevalence in this age group.

Lifetime asthma among Washington elementary school-aged children was greater for boys than girls (14.1% vs. 12.7% in 6th grade). During middle school years – which correspond with the onset of puberty – the relative prevalences reverse, and by late high school girls had a greater lifetime prevalence of asthma than boys (17.6% vs. 20.7% for 12th grade, see Figure 26). This change may reflect continued increases in lifetime asthma (incidence) among girls by grade, and a relatively stable lifetime prevalence of asthma among boys in 8th grade and older.

Figure 26: Prevalence of lifetime asthma by grade and gender, among Washington youth

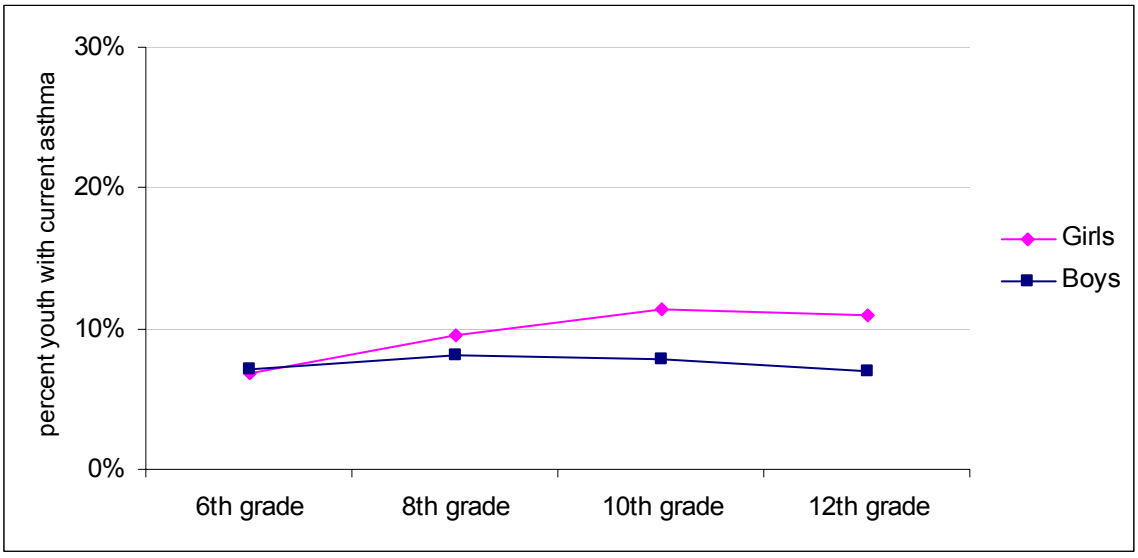


Source: combined 2002 and 2004 Washington State Healthy Youth Survey (HYS).

For current asthma, there was no difference between boys and girls for 6th grade, but in older grades girls were significantly more likely than boys to have current asthma (10.9% for girls vs. 7.0% for boys in 12th grade, see Figure 27).[§§] As demonstrated for lifetime asthma, the prevalence of having current asthma progressively increases by age/grade for girls, but not for boys.

[§§] Chi-square tests for association between asthma and gender within grades: 8th grade p=.02; 10th grade p<.001; 12th grade p<.001.

Figure 27: Prevalence of current asthma by grade and gender, among Washington youth



Source: combined 2002 and 2004 Washington State Healthy Youth Survey (HYS).

This gender reversal is not well-understood, despite having been widely noted.[25] [26] [27] The greater prevalence of current asthma among females in comparison to males persists during adulthood. Due to the timing of the reversal during puberty, a number of hypotheses have been explored regarding hormonal influences on asthma. It has been noted that progesterone can affect the regulation of beta-2-receptors, which enable relaxation of the bronchial tubes.[28] It has also been shown that estrogen, when administered to post-menopausal women as hormone replacement therapy, is associated with adult-onset asthma.[29] A case-control study of progesterone, estradiol and cortisol levels in women reported that at least one of the levels was out of normal range in 80% of the women with asthma.[30] Thus, hormones that become activated among females during puberty may contribute to asthma.

Other authors have proposed that sex-related differences in airway size may account for some of the differences in asthma prevalence,[31] [32] since airway size tends to be smaller in boys than girls during infancy, then reverses later. Small airways tend to be more compromised when exposed to a given allergenic stimulus, since flow through the airway depends on its radius.

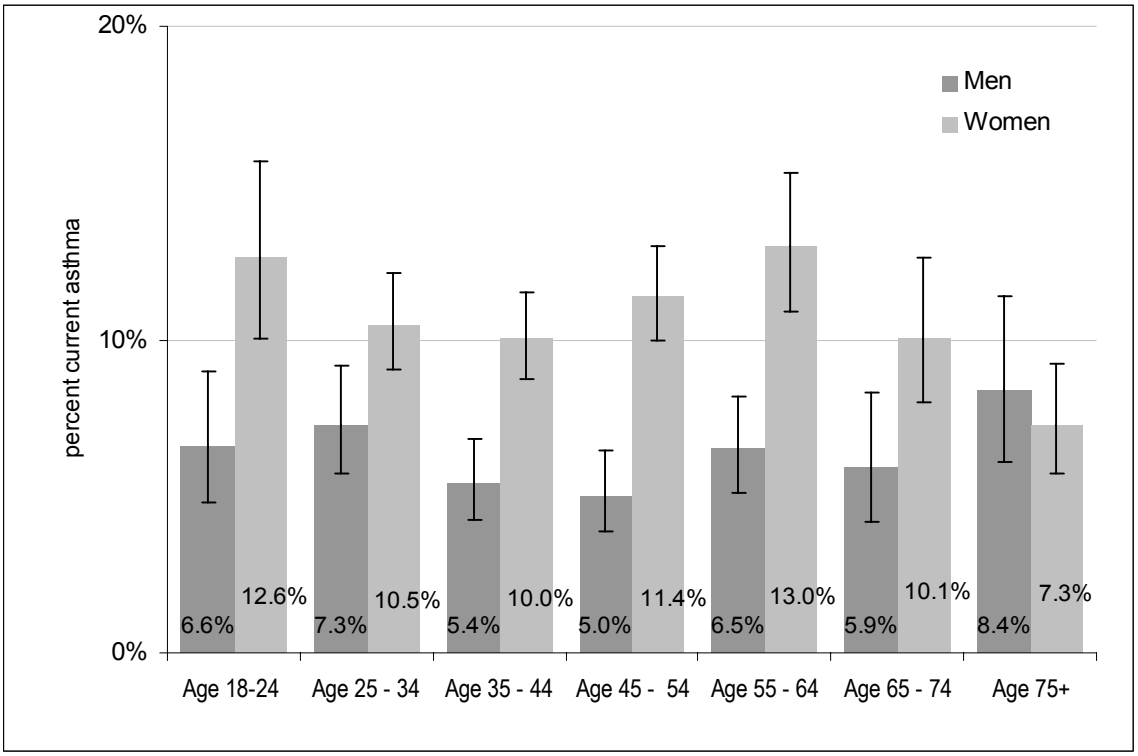
Adult Lifetime and Current Prevalence

Although asthma often begins in childhood, most adults with asthma were first diagnosed with asthma by a healthcare provider after age 18 (see Figure 19). Adult-onset asthma is more common in women, as evidenced by the reversal in the male-female prevalence ratios after puberty.

The prevalence of current asthma among Washington women (10.8%) was significantly higher than for men (6.2%) among all adult age groups combined and among all age groups younger than 75 (see Figure 28). Asthma prevalence increased with age among

women (p=.01), but was not significantly associated with age among men. Nationally, the 2000 median prevalence for women was 9.4% and 5.5% for men.[33] These adult gender differences in asthma prevalence have also been described in multiple national studies over the past 20 years. [25 27 30 34 35]

Figure 28: Prevalence of current asthma by age and gender, among Washington adults



Source: 2001-2003 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS)

A number of possible mechanisms have been suggested, including sex hormones, [28 29 36 37] differences in airway size and responsiveness, [32] or obesity.[28 38 39 40 41 42 43] Some investigators have proposed that women may have an increased likelihood of indoor environmental exposures,[44] or a greater likelihood of allergic disease,[45] which could contribute to higher rates of adult-onset asthma. Occupational exposures play a significant role (as much as 25%) in adult-onset asthma.[147, 148]

The female-male difference was not significant among Washington's oldest age groups (75 and older), where women had the lowest measured prevalence and males the highest measured prevalence of any adult age groups. It has been suggested that diagnosing asthma is difficult among older adults, where symptoms can be confused with other chronic respiratory illnesses and therefore some late-age diagnoses could be inaccurate (although others may remain undiagnosed for the same reason).[46]

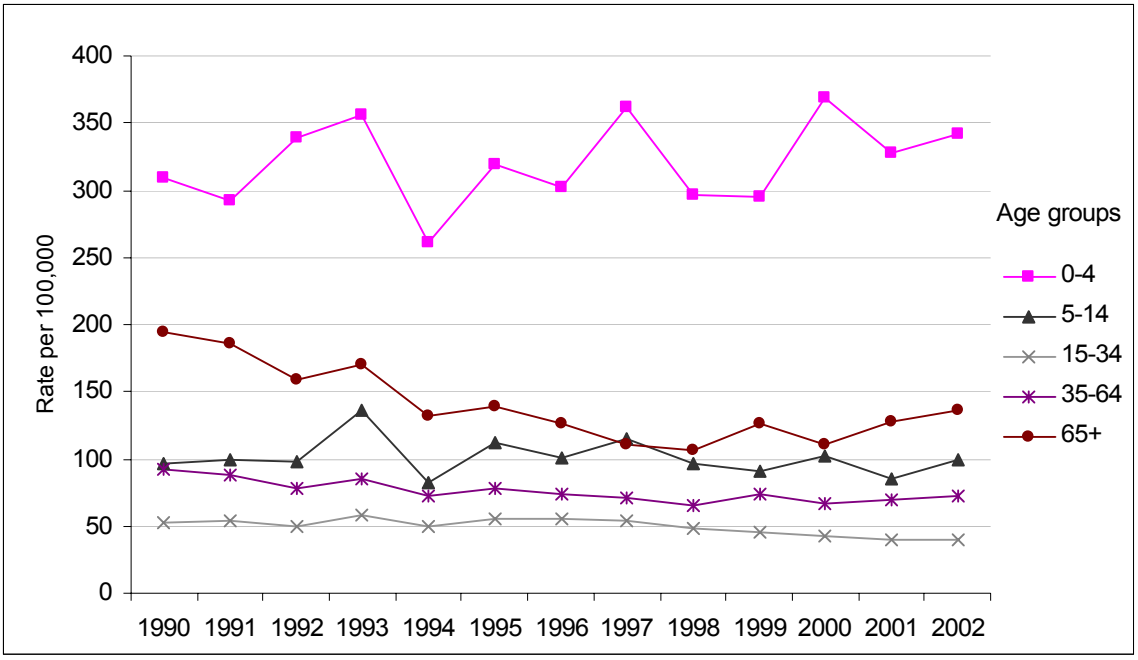
Hospitalization/Urgent Care

In contrast to prevalence rates, which are lowest for young children, children under five have the highest hospitalization rates – nearly ten times the 15-34 year old age group

(341.7 vs. 39.9 per 100,000). People age 65 and older also have comparatively higher hospitalization rates (136.4 per 100,000) in comparison to middle-aged groups although the prevalence is not greater. National hospitalization data indicate a similar pattern for hospitalization by age groups, with the highest rates occurring in infants and the elderly.[16]

Washington's overall hospitalization rate for asthma during the past 8 years has been very stable (see Figure 2). The stable trend in hospitalizations is, however, not uniform by age (see Figure 29). Slightly declining trends are observed among people aged five to 64 ($p=.001$ for ages 5-14; $p<.001$ for ages 15-34; $p<.001$ for ages 35-64; and $p<.001$ for ages 65+). In contrast, hospitalization rates have increased overall for young children (ages 0 to 4, $p=.003$) although with considerable year-to-year variation. Despite the substantial decline from 1990 to 1998 in rates for the elderly (65+), there were increases from 1998 to 2002.

Figure 29: Trends for Washington State asthma hospitalizations by age group



Source: Washington State Comprehensive Hospital Abstract Reporting System (CHARS). Asthma as principal diagnoses.

Several factors may explain why hospitalization rates are significantly different for younger and older people. First, "wheezing" is very common in young children, with prevalence rates of between 20-30% reported for children between 12 months and 5 years of age.[47] Given the variety of potential causes for acute wheezing illnesses among small children, including viral induced wheezing, many children are likely hospitalized for treatment without a clearly evident understanding of what is causing their symptoms. Some of these hospitalizations may be coded as asthma for billing purposes, overestimating the true incidence of asthma hospitalization.

Second, the "threshold for admission," or the seriousness of symptoms being experienced by an individual before they are admitted to the hospital for treatment, may be

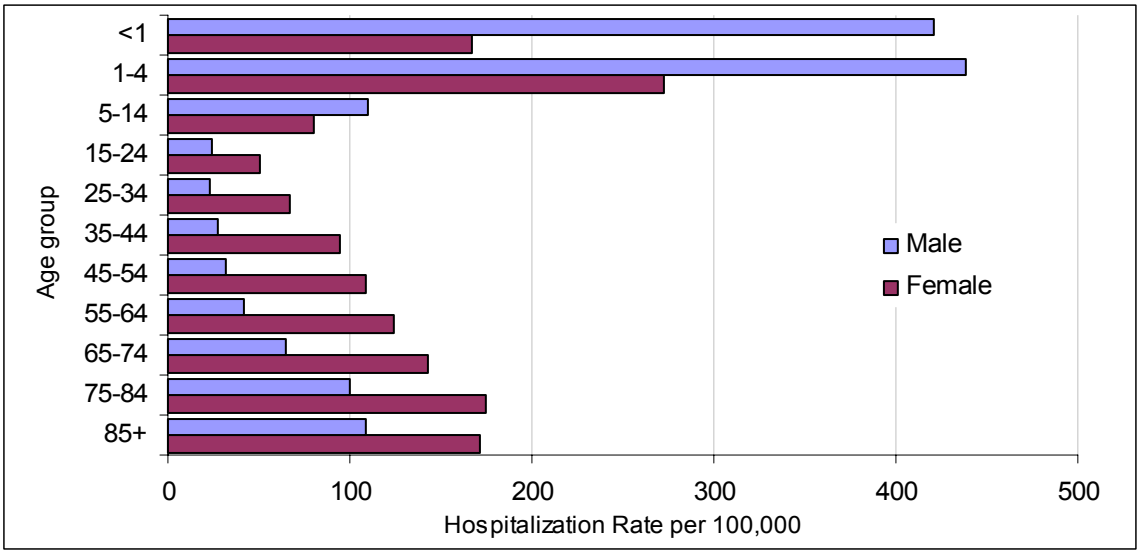
increasingly different for different age groups. The admission threshold for asthma has reportedly increased for older children and adults as medical systems increasingly avoid hospitalizations, but the threshold to hospitalize an acutely ill infant or toddler likely remains much lower. Social factors, such as family stress, could influence the decision to admit a young child, as well as the need for close, around-the-clock monitoring for respiratory difficulties. In addition to subjective forces influencing the decision to admit a young child, widespread use of new technology (pulse oximetry) in the evaluation of children having acute breathing difficulty has dramatically increased the sensitivity of detecting low blood oxygen concentrations (mild hypoxemia) and may contribute to increased likelihood of hospitalization.

Young children also have narrow airways which are more prone to obstruction in the course of a viral illness. At about age two, airway size increases and the incidence of viral bronchiolitis begins to wane, and the admission rate for both sexes decreases.[30]

The three most recent years of Washington hospitalization data (2000 to 2002) were combined to examine differences by age and gender more carefully.

Asthma hospitalization rates were higher among boys than girls under age 15 (see Figure 30). The reverse is seen starting at age 15, where it is more common for women to be hospitalized than men. This striking pattern is parallel to patterns observed in prevalence data (discussed previously) and has also observed nationally.[18]

Figure 30: Age and gender-specific Washington State hospitalization rates



Source: Washington State Comprehensive Hospital Abstract Reporting System (CHARS), 2000-2002 combined. Asthma as principal diagnosis.

Aside from background prevalence differences, reasons for higher rates of hospitalization among women in comparison to men have been widely investigated, but are as yet unexplained. There is some evidence that adult women with asthma are more likely to be seen as outpatients, to require an ED visit, or to be hospitalized than men, even after

accounting for their greater prevalence.[48] [49] Although one explanation is that women may have inherently more severe disease, it may also be the case that women have increased perception of symptoms and seek medical attention more often. Alternatively, women may receive less aggressive treatment than men, either because of their own behaviors, or provider practices.

National Objectives

Washington has not yet met Healthy People 2010 objectives for hospitalization among the young and the elderly. Washington hospitalization rates for 2002 were 336 per 100,000 for children under five, 68 per 100,000 for people age 5-64 (age-adjusted) and 138 per 100,000 for people 65 and older (age-adjusted).

Healthy People 2010 Objective 24-2*
Reduce asthma hospitalizations.

Targets:

- 250 per 100,000 for children younger than 5
- 77 per 100,000 for adolescents and adults ages 5-64
- 110 per 100,000 for adults age 65 and older

age-adjusted to year 2000 standard population for 5-64 and 65+ age groups

Data to describe rates of emergency department use in Washington are not available to measure relevant Healthy People 2010 goals; however, about one in ten adults and one in four middle-high school aged youth with asthma in Washington reported having visited an emergency department or urgent care facility in the previous year for asthma symptoms (see discussion Chapter II).

Healthy People 2010 Objective 24-3*
Reduce hospital emergency department visits for asthma.

Targets:

- 800 per 100,000 for children younger than 5
- 500 per 100,000 for adolescents and adults ages 5-64
- 150 per 100,000 for adults age 65 and older

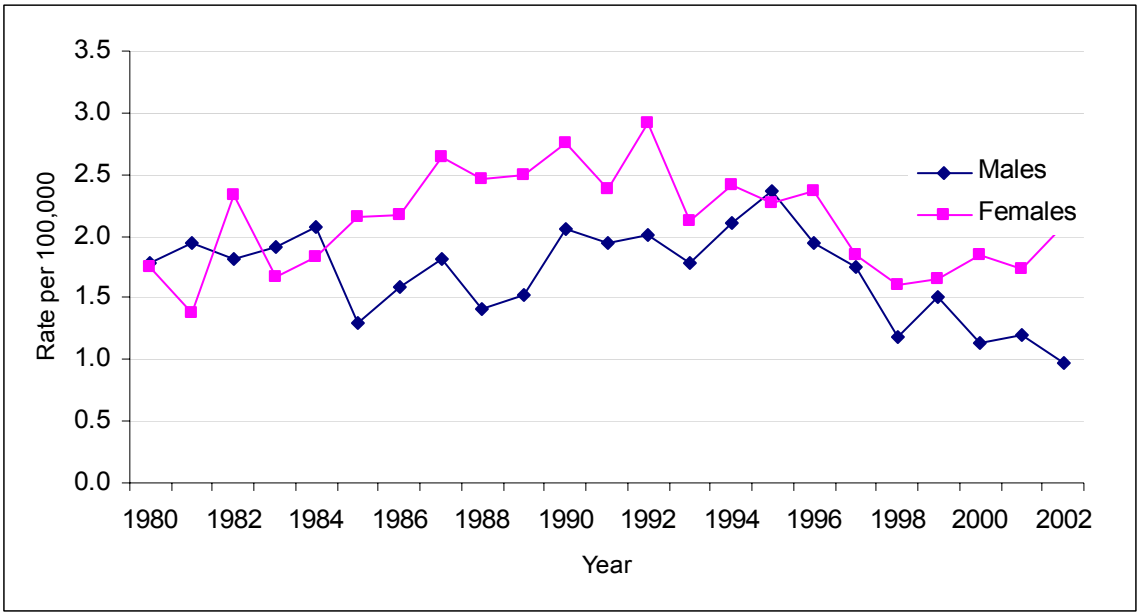
age-adjusted to year 2000 standard population for 5-64 and 65+ age groups

* HP2010 goals presented "per 10,000" in national documents

Deaths

In Washington State between 1980 and 2002, the mortality rate for asthma has tended to be mostly higher for women than men (see Figure 31). This is consistent with gender-specific asthma mortality data from the United States as a whole.[16] Although death rates for men and women have declined since the early 1990s, the decline among women seems to have leveled off in the past several years.

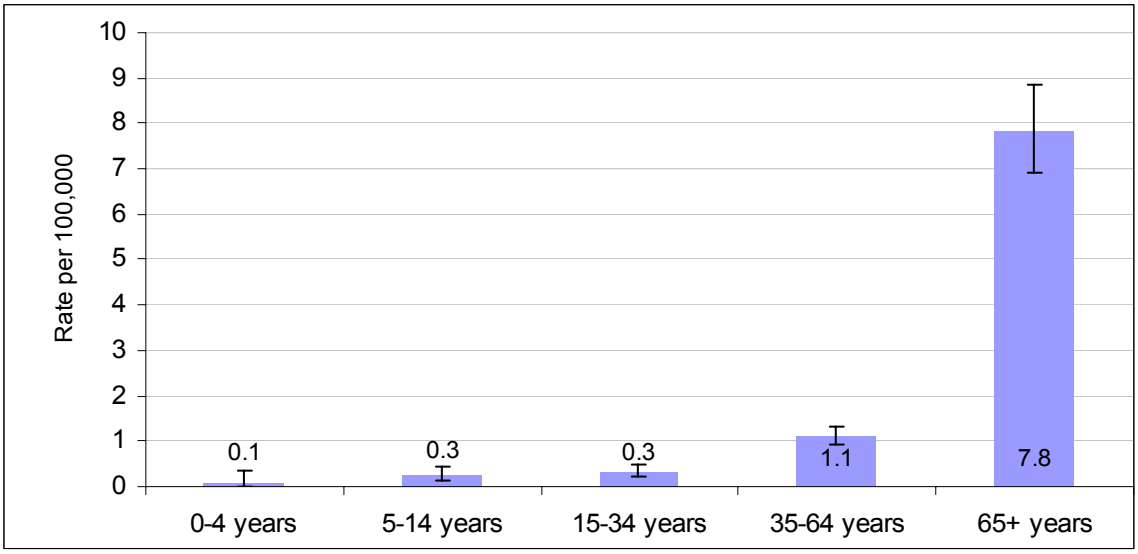
Figure 31: Trends for Washington asthma deaths by gender



Source: 1980-2002 National Death Certificates, Washington State Death Certificates
Asthma as primary cause of death, age-adjusted to 2000 US Population.

Data from 1998-2002 death certificates were combined to create age-specific death rates (see Figure 32). Among children younger than five, there were fewer than five deaths during this period; among children ages five to fourteen there were 11 deaths; among people ages 15-34 there were 28 deaths; among people ages 35-64 there were 127 deaths; and among those 65 and older there were 260 deaths.

Figure 32: Washington State asthma death rates by age group



Source: 1998-2002 combined National Death Certificates, Washington State Death Certificates
Asthma as primary cause of death.

Despite a significantly higher asthma hospitalization rate in Washington State among children under age 5, the asthma mortality rate in this age group is lower than for any other age group. In contrast, asthma can be more dangerous among older adults because they can develop respiratory failure more quickly.[50] About 60% of the total deaths from asthma occur among people age 65 and older.

National Objectives

Washington has not yet met Healthy People objectives for asthma deaths except among children younger than five. The small number of deaths each year among people younger than 65 results in unstable annual estimates (or even five-year estimates) that are unlikely to exhibit measurable change within the next ten years.

Healthy People 2010 Objective 24-1*
Reduce asthma deaths.
Targets:

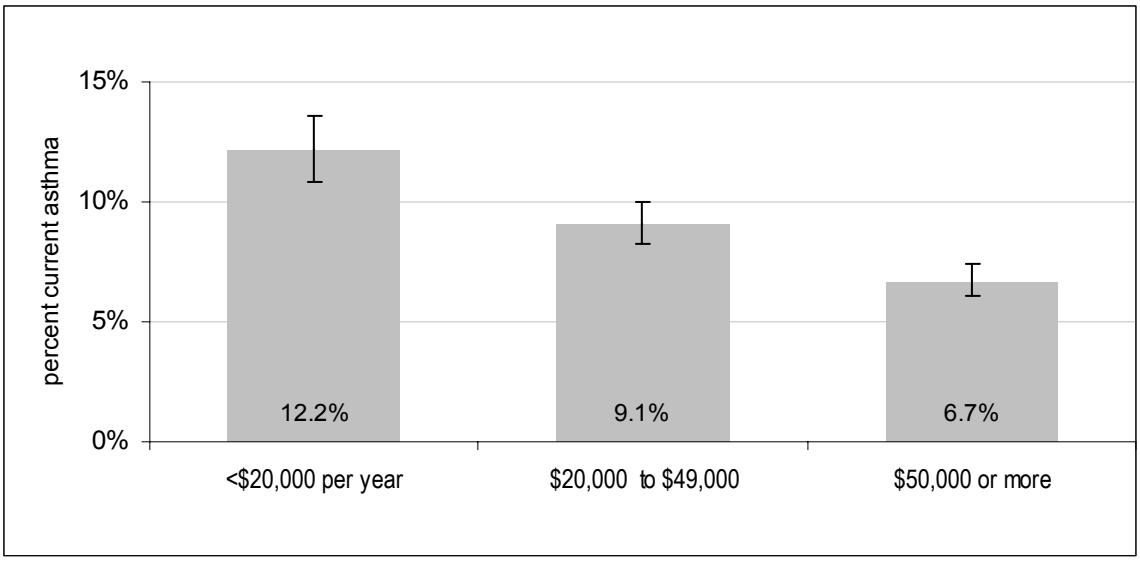
- 0.1 per 100,000 for children younger than 5 and ages 5-14
- 0.2 per 100,000 for adolescents and adults ages 15-34
- 0.9 per 100,000 for adults ages 35-64
- 6 per 100,000 for adults age 65 and older

B. Income and Education

Prevalence

Asthma prevalence was higher in adults with an annual income of less than $20,000 compared to those with incomes of $20-49,000 and over $50,000 per year (see Figure 33, p<.001). Adults in the lowest income group had nearly double the prevalence of asthma in comparison to adults in the highest income group. The same pattern has been shown nationally: a large study based on the National Health and Nutrition Examination Survey showed that lower income was the strongest independent predictor of prevalent asthma in both blacks and whites.[51]

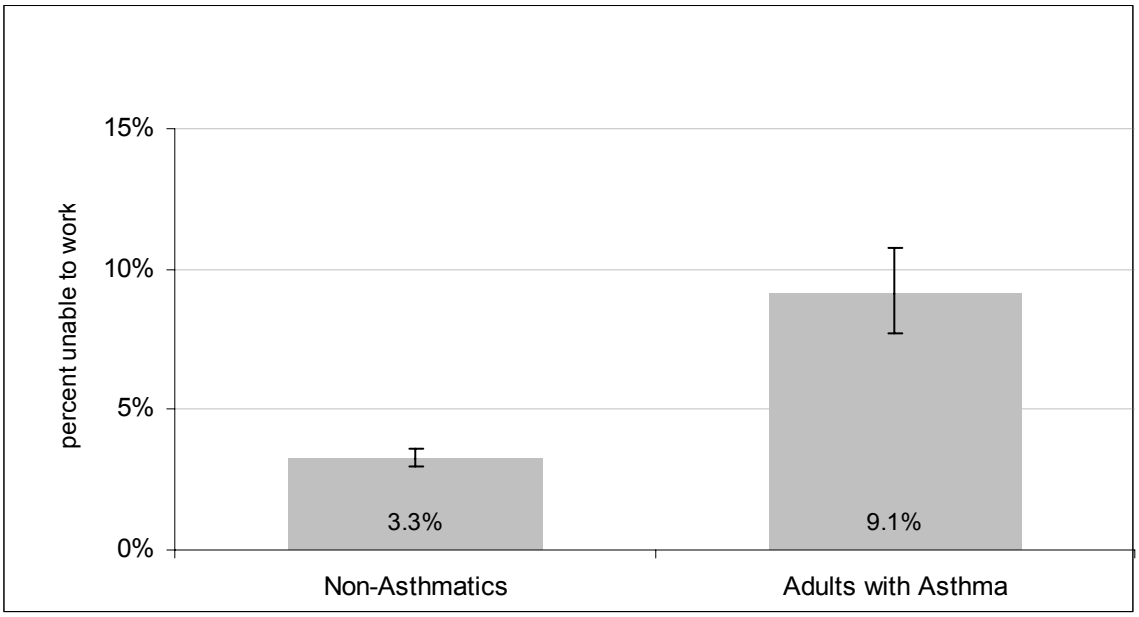
Figure 33: Asthma prevalence by income category, among Washington adults



Source: 2001-2003 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Washington adults with asthma were nearly three times as likely as adults without asthma to report being unable to work (see Figure 34). It is not known what proportions of these people are not working because of work-related asthma, non-work-related asthma, or a work-prohibitive disability unrelated to asthma.

Figure 34: Prevalence of inability to work by asthma status, among Washington adults

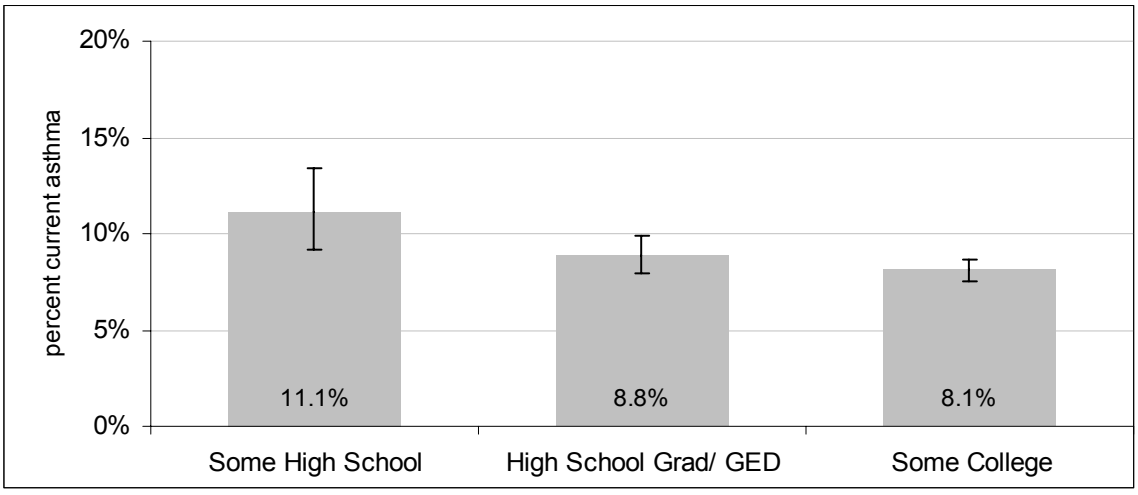


Source: 2001-2003 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS). Ages 65+ are excluded.

Washington data for youth asthma prevalence by family income level were not available. National studies indicate that children in poor families (15%) are more likely to have been diagnosed with asthma than children in families that are not poor (12%). Children in single-mother families (16%) were more likely to have ever been diagnosed with asthma than children from two-parent families (11%).[52]

Education is strongly associated with income status. Therefore it is not surprising that progressively lower prevalence of asthma was observed with increasing educational attainment among adults (see Figure 35, $p<.005$).

Figure 35: Prevalence of asthma by educational attainment, among Washington adults



Source: 2001-2003 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS).

There are several possible reasons for a higher prevalence of asthma for adults in lower socioeconomic groups. These include greater exposure to indoor and outdoor environmental pollutants such as tobacco smoke, particulate exhaust, and/or environmental allergens (dust mites, cockroach particles, and animal dander), and/or greater prevalence of risk factors (smoking, obesity). Some studies have also pointed to lower quality primary care.[53] [54]

Recalling the associations between self-reported academic achievement and asthma severity among youth (see Figure 16), and considering national studies that have indicated asthma is associated with frequent school absences,[55] [56] it is possible that asthma contributes to decreased educational status. Also, people with asthma were more likely to report being unable to work. Considering these findings, the person with asthma may potentially be at risk for lower income status – in other words, the relationship may go both ways.

Hospitalization/Death

Personal income and education are not identified as part of Washington's Death or Hospitalization data systems.

Discussion

Studies examining the link between socioeconomic status and asthma confirm that the impacts of asthma are greatest on low income populations. [21] [22] [57] For example, in the U.S. in 1996, pediatric hospitalizations for asthma were estimated to be five times higher for children in lower income families.[23] The National Cooperative Inner-City Asthma study demonstrated that over 50% of study participants, poor children living in inner cities, found it difficult to get follow-up asthma care. Among those with severe asthma, less than half were using anti-inflammatory medication. [58]

C. Race/Ethnicity

Washington's population is more than 80% white non-Hispanic. Historically, it has been difficult to describe any minority populations individually because of small numbers of any one race/ethnic minority group were included in public health surveillance systems. Fortunately, recent administrations of adult and youth surveys have increased sample size sufficiently to create such estimates.

Prevalence

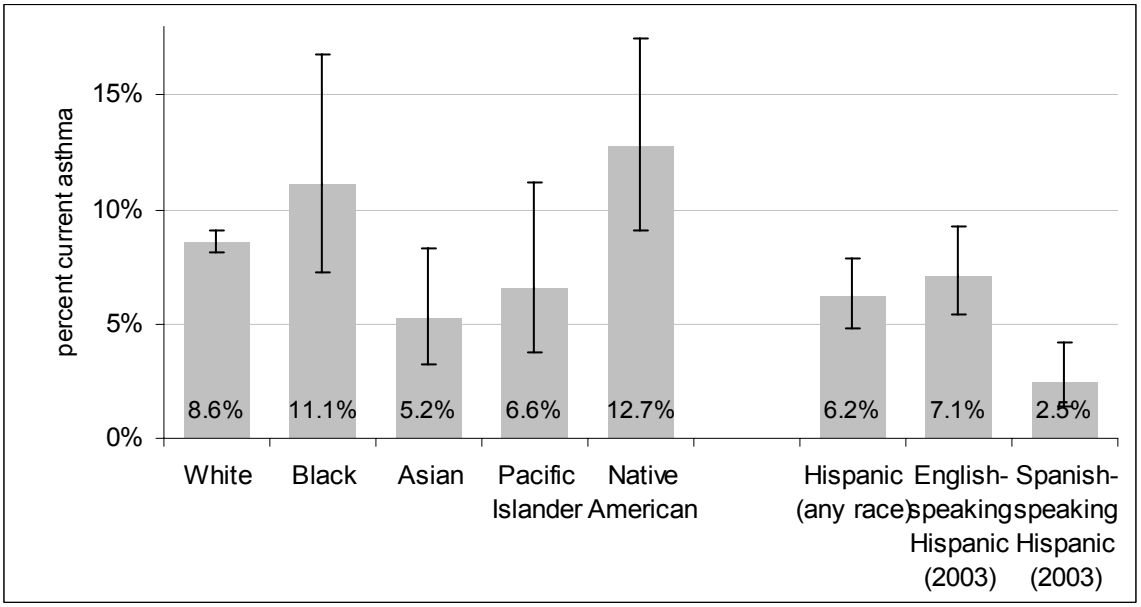
The prevalence of asthma among Washington adults was significantly lower for Asians and Hispanics (any race) than for non-Hispanic whites (see Figure 36). Asthma prevalence was higher among Native Americans than among non-Hispanic whites.[***] All other race/ethnic groups were similar to whites, although the small numbers prevent meaningful conclusions.

Spanish language was added to the Washington BRFSS in 2003, for the first time allowing inclusion of Spanish-speaking Hispanics in the survey as well as stratification of Hispanics by language spoken as a measure of acculturation or adoption of "mainstream" Washington culture. In 2003, Spanish-speaking Hispanics were significantly less likely than English-speaking Hispanics to report having asthma. English-speaking Hispanics were similar to non-Hispanics in reported prevalence of asthma.

Spanish-speaking Hispanics are likely to be recent (or first generation) immigrants, while English-speaking Hispanics may be second generation or more. Previous studies have documented important health differences among Hispanics by acculturation; for example, less acculturated Hispanic women are much less likely to smoke than more acculturated Hispanic women.[59]

[***] Each group was compared to white/non-Hispanics in a logistic regression model for association of race/ethnicity with asthma: p=.007 for Native American, p=.03 for Asian; p=.009 for Hispanic vs. non-Hispanic (any race) and p<.001 for Spanish-speaking vs. English-speaking Hispanics.

Figure 36: Prevalence of asthma by race/ethnicity, among Washington adults

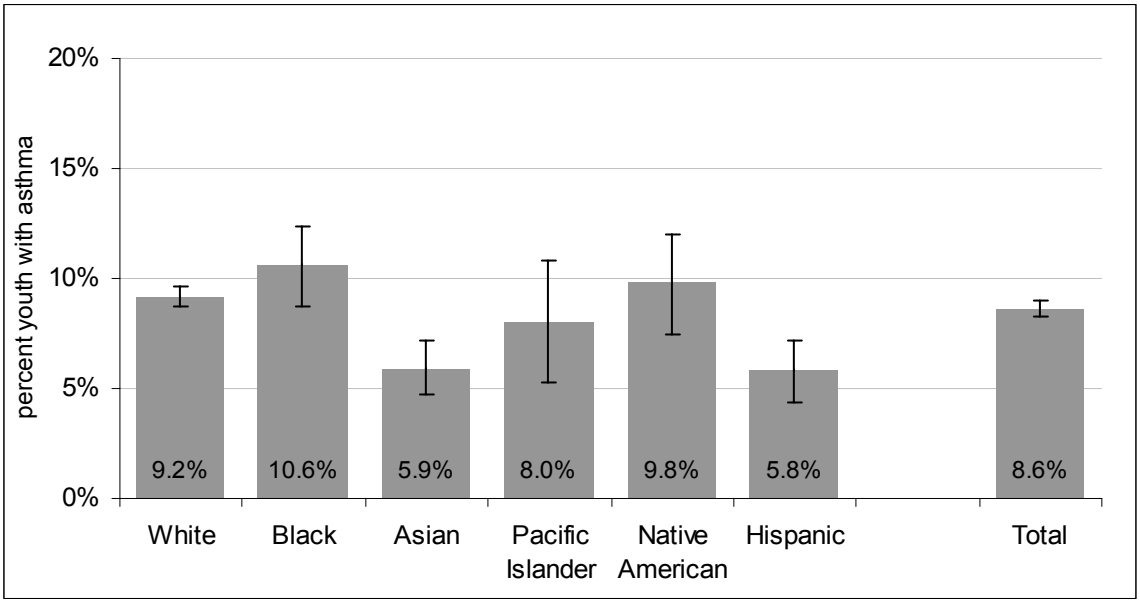


Source: 2001-2003 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS). Hispanic ethnicity collected separately from race.

Among youth, Asians and Hispanics were again less likely than White non-Hispanics to have asthma, but significant differences between non-Hispanic whites and other groups were not found (see Figure 37).[†††] This survey does not allow for distinction of English from Spanish-speaking Hispanics.

[†††] Odds for current asthma were .6 ($p<.001$) for both Asian and Hispanic youth in comparison to white non-Hispanic youth, after adjustment for grade.

Figure 37: Prevalence of asthma by race/ethnicity, among Washington youth



Source: combined 2002 and 2004 Washington State Healthy Youth Survey (HYS), 6-8-10-12th grade-standardized. Race and Hispanic ethnicity collected as part of a single question.

Hospitalization/Death

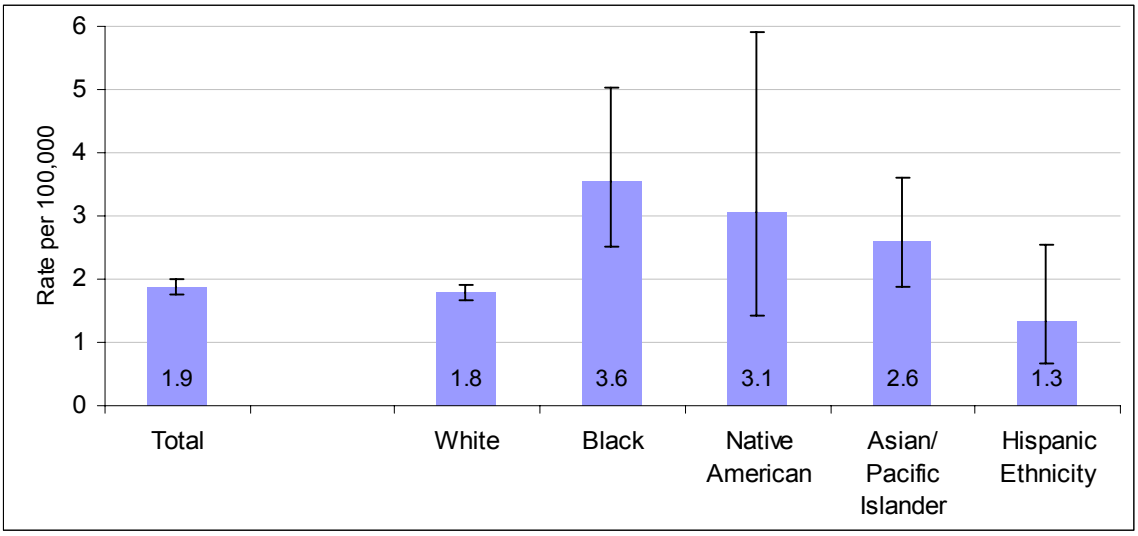
Washington's hospitalization data collection system does not include information about race or ethnicity of the patient; therefore we do not know whether that burden is different for different groups. National data for adults indicate that women of within all races have higher rates of illness and death from asthma than men,[16] so we would expect that within any minority group women in Washington would also have higher hospitalization rates than minority men.

To create meaningful estimates of asthma death rates in Washington among race and ethnic groups, ten years of Death Certificate data were combined. Age-adjusted death rates for Blacks, Native Americans, ‡‡‡ and Asian/Pacific Islanders were all higher than for whites (see Figure 38). Hispanics were similar to whites. These differences in death rates are disturbing because only for adult Native Americans were asthma prevalence estimates greater than for non-Hispanic whites. This may indicate that minority group members with asthma have less access to care or quality care for their asthma.

It is important to recognize that the actual numbers of deaths are small, therefore even a few deaths prevented among small subgroups could substantially change the death rate. During 1992-2001 there were 49 asthma deaths among Blacks, 13 among Native Americans, 50 among Asian and Pacific Islanders, 14 among Hispanics, and 851 among whites – a total of 963 deaths.

‡‡‡ Although Native American difference was non-significant at p=.06, rates are expected to be underestimated based on under-reporting of Native American race in Death Certificate data (see discussion on Death Certificate data in Appendix A)

Figure 38: Washington death rates from asthma by race/ethnicity



Source: 1992-2001 combined Washington State Death Certificates Asthma as primary cause of death, age-adjusted to 2000 US Population. No comparability ratios were used to account for 1998 change from ICD-9 to ICD-10 codes.

Discussion for Individual Race/Ethnic Groups

Although asthma affects Americans of all ages, races, and ethnic groups, low-income and minority populations experience substantially higher rates of fatalities, hospital admissions, and emergency department visits due to asthma.[57] Several reports[54 60] have indicated that observed racial/ethnic disparities are attenuated but do not disappear upon adjustment for socioeconomic factors.

In the United States, the prevalence of asthma for nonwhites is only slightly higher than for whites, yet the death, hospitalization, and Emergency Department visit rates for non-whites are more than twice those for whites. Although reasons for these differences are unclear, they likely result from multiple factors: high levels of exposure to environmental tobacco smoke, pollutants, and environmental allergens/triggers (for example, house dust mites, cockroach particles, cat and dog dander, and possibly rodent dander and mold); a lack of access to quality medical care; and a lack of financial resources and social support to manage the disease effectively on a long-term basis.[61] Research into the role of socioeconomic factors is needed to identify additional prevention opportunities.

Black/African American

In 2002, National Health Interview Survey data documented that the current asthma prevalence among African Americans was 38% higher than in whites (9.6% vs. 6.9%).[21] National hospitalization rates for asthma, reported on the National Hospital Discharge Survey, are over three times higher for blacks than for whites, (36 per 10,000 vs. 11 per 10,000).[22] African Americans are approximately five times more likely than whites to seek care for asthma at an emergency department.[62]

The prevalence of current asthma among African Americans in Washington was not significantly different than among non-Hispanic whites, but death rates were significantly

greater. This is similar to national findings and suggests an important health disparity within the population for control of asthma.

Asian/Pacific Islander

There are few studies on asthma among Asian/Pacific Islanders. The "Asian" or "Pacific Islander" categories actually represent a grouping of many culturally diverse sup-groups (e.g., Korean, Japanese, Native Hawaiian, Laotian peoples). More information to describe patterns of exposure, treatment and knowledge within these subgroups is necessary to understand the burden of asthma within communities.

For both adults and youth in Washington the prevalence of asthma among Asians was lower than for non-Hispanic whites, and Pacific Islanders were similar. The death rate for Asian and Pacific Islanders combined was greater than for whites. This suggests an important health disparity within the population for control of asthma.

Native American/American Indian/Alaskan Native

National surveillance data to describe asthma among Native Americans are limited. One paper examined asthma prevalence among American Indian and Alaska Native (AI/AN) children using 1987 National Medical Expenditure Survey data, and reported a prevalence of 7.1% among AI/AN children 0-17, compared with a national estimate of 8.4% for all children 0-17 (these estimates were not significantly different).[63] However, no stratification could be done for income or rural/urban residence, two factors where AI/AN children differ substantially from whites, and which are highly related to asthma prevalence and severity. In a second report on AI students (6th grade through 9th grades) 7.4% of students said they had ever received a diagnosis of asthma from a doctor.[64] A report on hospitalization trends, relying only on data from the Indian Health Service (IHS), showed increases similar to those for white children (about 2.6% per year from 1979 to 1989.) [65]Another report, based on Washington State data, showed similar hospitalization rates for AI/AN children compared to children of all races, except for infants, whose rates were over twice as high, with sharply increasing trends from 1987 to 1991.[66]

Adult Native Americans had a higher prevalence of asthma than non-Hispanic whites, and also higher rates of death. This suggests that there are important disparities in factors related to the development of asthma and control of asthma.

Hispanic/Latino

Hispanics are the fastest-growing minority group in Washington State. The 2000 Census indicated that 7.5% of Washington's population is Hispanic/Latino, with that population size projected at greater than 500,000 by 2003, and 11 of Washington's 39 counties have more than 20 percent Hispanic population.[67]

Hispanics who take health surveys in Spanish may be considered "less acculturated" to the mainstream population and exhibit different risk or health behaviors, including some healthier behaviors such as lower rates of cigarette smoking.[68, 59] However, people who do not speak English and who are employed in agriculture may also have increased

exposure to irritating chemicals, and if part of the migrant farmworker population they would not be captured in random-digit-dial telephone surveys. Therefore, the low rate of asthma reported for this group is potentially an underestimate. Also, less acculturated Hispanics are more likely to live in poverty and have less access to healthcare support for preventive care or clinical control of asthma or other conditions.[69]

Current asthma prevalence among Washington Hispanic youth and adults overall was significantly lower than non-Hispanic whites, but for adults we were able to stratify by language (as a measure of acculturation) and there was no difference in asthma prevalence between English-speaking Hispanics and non-Hispanics. It has been reported that there is substantial variation in asthma prevalence between Hispanic sub-groups, with Puerto Ricans reporting the highest prevalence.[70] Washington's Hispanic population originates predominantly from Mexico.

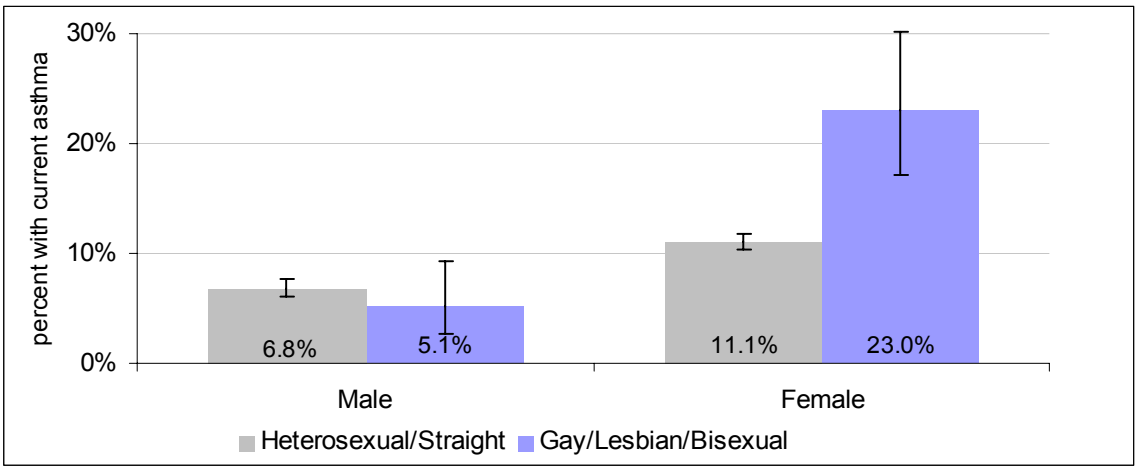
Considering the rapid growth of Hispanic/Latinos, similar health burden of asthma among more acculturated subgroups, and lack of access to care, these groups deserve attention. For less acculturated (Spanish-speaking) Hispanics, where data indicate a lower prevalence of asthma than among non-Hispanics opportunities may exist to assure prevention of work-related asthma and access to care. Without such focused attention, efforts to improve asthma risks and outcomes that are directed to the "mainstream" population may fail to reach Hispanic/Latino groups such that new disparities are created.

D. Sexual Orientation

Prevalence

Beginning in 2003, the BRFSS telephone survey included a question about sexual orientation. Gay and bisexual men, as well as lesbian and bisexual women were combined for comparison to their heterosexual (straight) counterparts. Lesbian/bisexual women were twice as likely to report having asthma than straight women, but there was no significant difference between gay/bisexual men and straight men (see Figure 39).

Figure 39: Asthma prevalence by sexual orientation within gender, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Hospitalization/Death

Sexual orientation is not identified in either hospitalization or death data. There are also no national data sources about morbidity and mortality from asthma in these groups.

Discussion

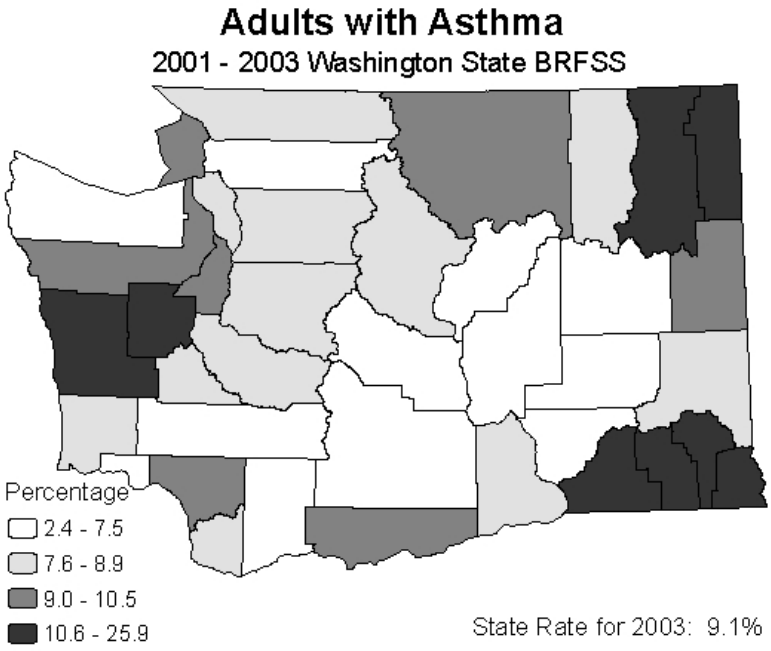
Sexual minority groups are gaining attention as an important group to consider for chronic disease prevention. For example, the prevalence of cigarette smoking among gay/bisexual men and lesbian/bisexual women is approximately double that of their heterosexual counterparts.[71] Higher prevalence rates for current asthma among lesbian/bisexual women suggest a need for focused efforts to reach this population group.

E. Geographic Area

Prevalence

Although there were not statistically significant differences among counties for asthma prevalence, prevalence estimates varied (see Figures 40, county-level prevalence estimates with population size estimates are included in Appendix D). County-level estimates for prevalence of current asthma among adults ranged from 2% to 26%.

Figure 40: Asthma prevalence by county, among Washington adults

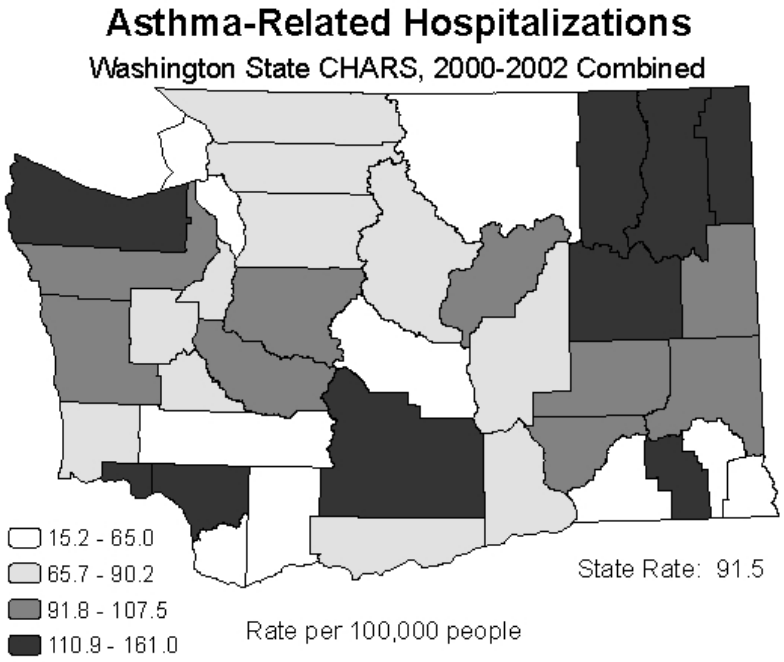


Source: 2001-2003 combined Washington State Behavioral Risk Factor Surveillance System (counties); state rate for 2003 only.

Hospitalization/Death

Hospitalization rates differed among Washington counties with no obvious geographic pattern (see Figure 41). Rates ranged from 15 to 161 per 100,000.

Figure 41: Hospitalization rates by county for Washington State



Source: 2000-02 combined Washington State hospitalization records (CHARS)

Discussion

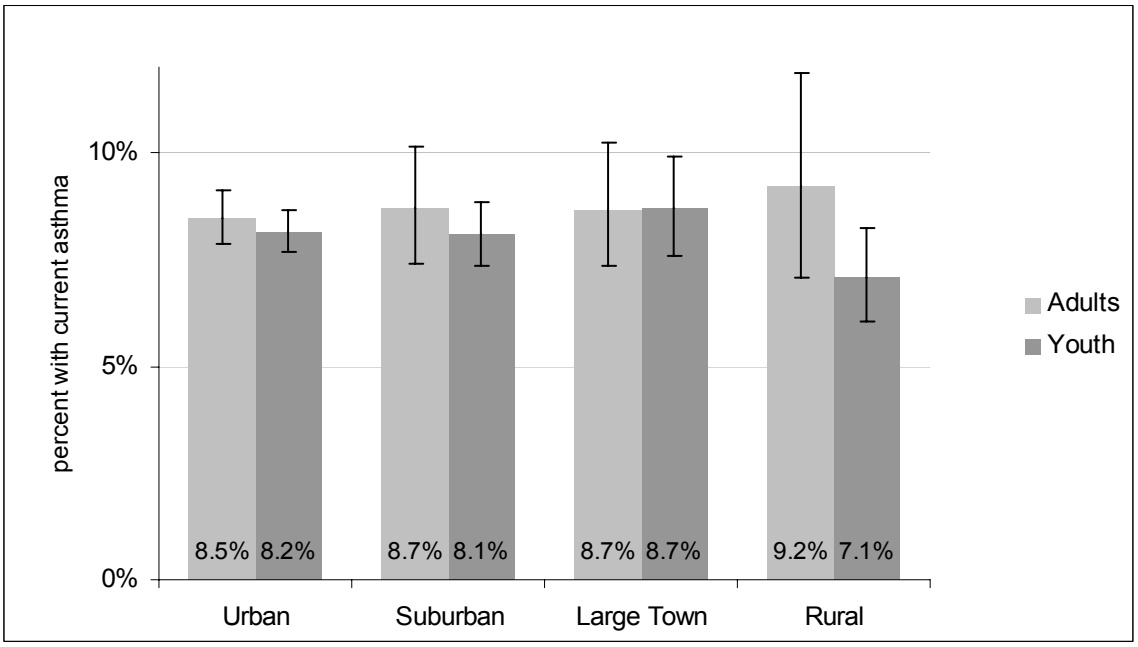
Stevens, Pend Oreille, and Columbia Counties all were among the highest group for both hospitalization and adult prevalence of asthma, but there were no other obvious geographic patterns or in county-level prevalence or hospitalization rates. Lack of patterns in burden may be partly due to variability in estimates and partly due to unique characteristics of Washington counties that influence asthma prevalence and hospitalization. For example, differences in county-level hospitalization rates may be related to different availability of routine healthcare services for preventive or mild acute care in different regions of the state, including geographic/transportation or economic barriers to care. A lack of pattern suggests that asthma program planning may benefit from a county-by-county analysis of risk factors, support systems and populations.

F. Urban and Rural Communities

Prevalence

For both adults and youth, there were no consistent differences in asthma prevalence by urban or rural community types (see Figure 42), although the prevalence of asthma among youth in rural areas was less than for urban areas.

Figure 42: Prevalence of asthma by community type, among Washington adults and youth

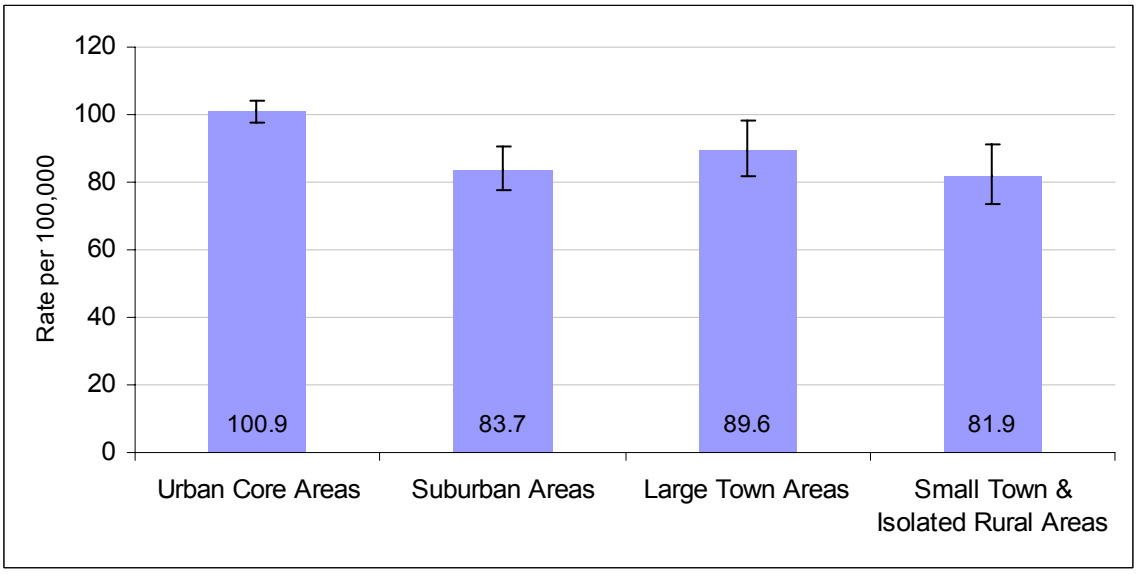


Source: 2001-2003 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS); 2002 and 2004 combined Washington State Healthy Youth Survey (HYS)

Hospitalization/Death

Urban communities have the highest rates of hospitalization, and are significantly greater in comparison to more rural community types.

Figure 43: Washington asthma hospitalization rates by community type



Source: Washington State Comprehensive Hospital Abstract Reporting System (CHARS), 2002. Asthma as principal diagnosis, rate per 100,000. RUCA assigned by patient zipcode. Age-adjusted to year 2000 standard US population.

Discussion

More than half of Washington adults with asthma live in urban communities (55%), while 18% live in suburban, 11% live in large towns, and 19% live in rural areas. Prevalence is not substantially different by community type, but excess hospitalization rates in urban settings indicate that attention in these areas for asthma programs may be warranted.

Researchers have examined urban residence as a risk factor for asthma, and found that after controlling for various factors such as race or income, all urban children were at increased risk for asthma.[72] Other studies[11 28 51 54 60 72 73 74] have pointed out that urban characteristics such as increased exposures to air pollution (from inner-city residence), overcrowding, and greater exposure to irritants such as cockroach allergens, are the among factors that partially account for observed racial disparities in asthma prevalence, morbidity and mortality.

V. Individual Risk Factors

In addition to association with demographic characteristics, such as age and gender, asthma is associated with other individual level risk factors. These include characteristics of people that are determined on a person-by-person basis, and which make an individual person more vulnerable to development of asthma or to environmental exposures that cause asthma. Some are within an individual's control, such as smoking. Others are not, such as genetic risk.

A. Cigarette Smoking

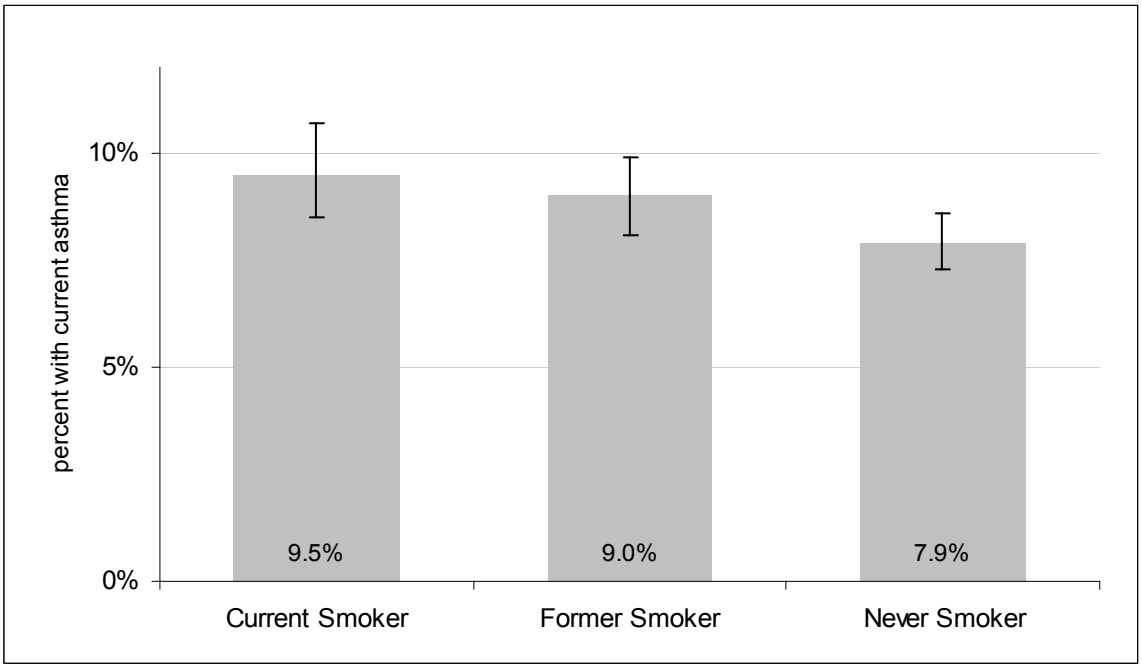
Active Smoking

Tobacco smoke is a well-documented potent trigger for asthma. There is conflicting evidence as to whether active smoking is a risk factor for asthma. Some studies have shown no association, or a weak association, [29] [51] [75] [76] [77] while others have demonstrated a clear association.[78] [79] The possible link between asthma and smoking is difficult to study for a number of reasons. Smokers who develop asthma may have higher quit rates than those without asthma.[77] Persons with sensitive airways may be less likely to initiate smoking.[29] Another issue is that smokers who develop emphysema or other smoking-related respiratory illnesses may be misclassified as having asthma[26] and if this were the case, smoking would appear to be associated with asthma.

Researchers agree that smokers with asthma have more severe symptoms than people with asthma who don't smoke. The Epidemiological Study on the Genetics and Environment of Asthma[77] found that current smokers had more asthma symptoms, more frequent attacks, and higher severity scores. In another study, smokers' asthma symptoms were more likely to affect their daily activities than nonsmokers.[80] Several studies have also found that asthma severity is related to duration of smoking.[77] [79]

In Washington, smoking history was associated with current asthma (see Figure 44, p=.02). Current smokers (people who smoke every day or just on some days, combined) had the highest prevalence of asthma, former smokers somewhat less, and never-smokers had the lowest prevalence of current asthma.

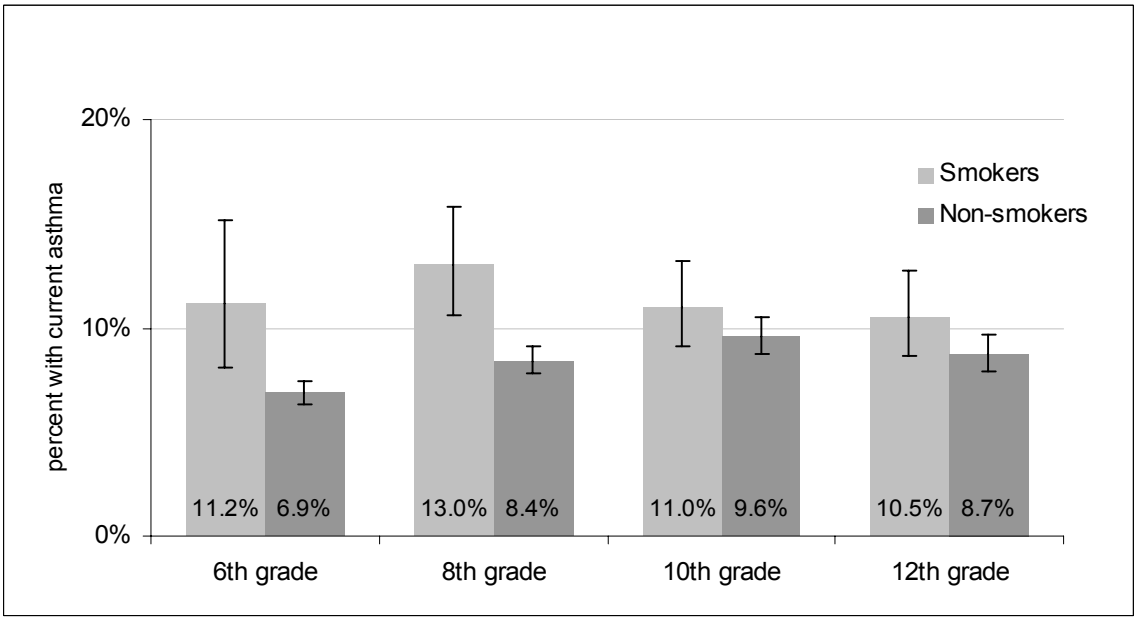
Figure 44: Asthma prevalence by cigarette smoking status, among Washington adults



Source: 2001-03 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Among Washington middle school-aged youth (p=.003 for 6th grade; p<.001 for 8th grades) current smoking is strongly associated with asthma, but the association is not significant for high school-aged youth (see Figure 45).

Figure 45: Asthma Prevalence by cigarette smoking status among Washington youth



Source: 2002 and 2004 combined, Washington State Healthy Youth Survey (HYS)

The data suggest that early initiation of smoking may be a risk factor for asthma; however, other factors may explain the association seen here between youth smoking and asthma. Smoking is associated with socio-economic status (youth from lower income families smoke more[81] and are also at increased risk for asthma). Also, youth who smoke may be more likely to have additional exposure to secondhand smoke at home, which is recognized as a potent trigger for asthma among children. [82] [83] These associations may also be related to maternal smoking during pregnancy, which has been shown repeatedly to be associated with an increased risk of asthma among children, in some, though not all, studies.[84] [85] [86] [87]

Maternal Smoking during Pregnancy

The association between childhood asthma and maternal smoking during pregnancy has been inconsistent. Researchers face some difficulty in separating prenatal from postnatal exposure, as most mothers who smoke during pregnancy continue to smoke after delivery. A summary review concluded that although there are a number of studies indicating that prenatal exposure may elevate risk, postnatal exposure is likely more important. [86] However, one recent study which included women who reported successful long-term smoking cessation and no household smoking, reported an 80% increased risk of asthma in their children.[85] Other recent evidence has related *in utero* exposure to decreased lung growth in all children, with more severe changes in children with asthma.[88]

Smoking during pregnancy has been gradually declining over time in Washington. In 2003, 10.9% of mothers reported smoking during pregnancy. This translates into between 7,000 – 8,000 infants born to mothers who smoke during pregnancy. [89] Smoking during pregnancy has been addressed by a number of public health programs because of a variety of adverse health effects for the mother and child,[90] so asthma is only one among many reasons to continue these interventions.

B. Obesity

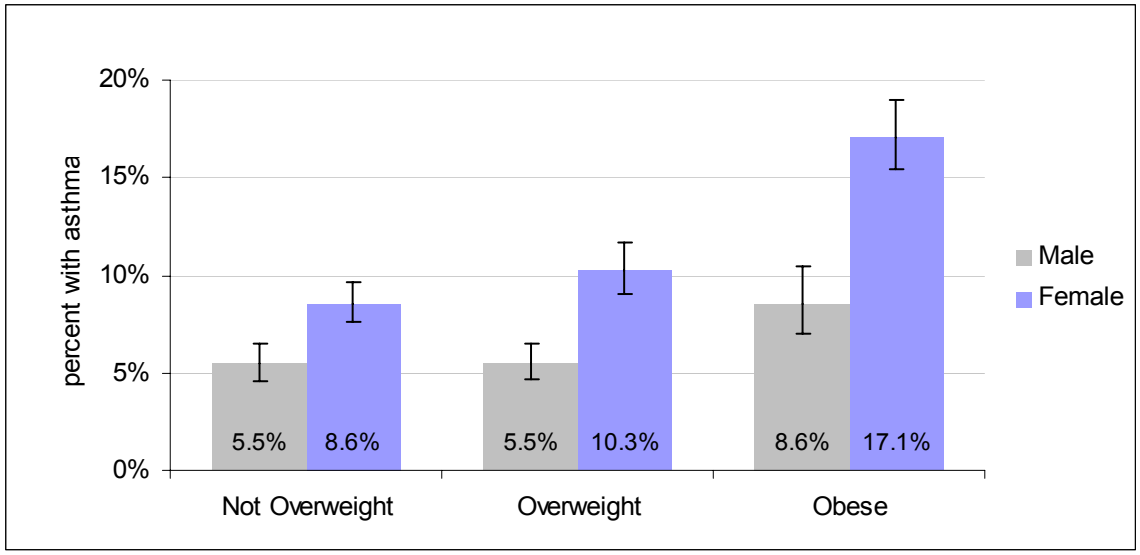
Among Washington adults, increasing levels of overweight[§§§] were significantly associated with increasing prevalence of asthma for women and men (see Figure 46). Nearly one in five obese women reported having asthma in contrast to one in ten women who were not overweight. Among men, the prevalence of asthma was lower than for women within all bodyweight categories, and the prevalence for overweight and not overweight men was similar (6%) but higher for obese men (9%).

Multiple studies, including a few longitudinal studies, suggest an association between higher body mass index and a higher prevalence of asthma or greater risk of developing asthma, especially in women.[91] [92] [93] Evidence exists that weight loss in obese people with asthma decreases symptoms and morbidity, and improves lung function.[94] Clear explanations for a link between obesity and asthma prevalence are lacking, but some

[§§§] See technical notes for discussion of overweight and obesity measurement. Significant association between current asthma and obese (vs. overweight or not obese): p<.001 for women, p=.004 for men.

evidence exists that estrogens may be a risk factor for asthma,[29] and in women obesity may be associated with higher levels of bio-available estrogens.[91] Other suggested mechanisms include chest wall restriction with a resultant decrease in airway caliber, increased bronchial reactivity, and/or an increase in gastro-esophageal reflux disease.[91] The prevalence of obesity in Washington State has doubled over the past decade[95] and if obesity is causal for asthma this could explain some of the statewide increase in asthma prevalence.

Figure 46: Asthma prevalence by bodyweight and gender, among Washington adults



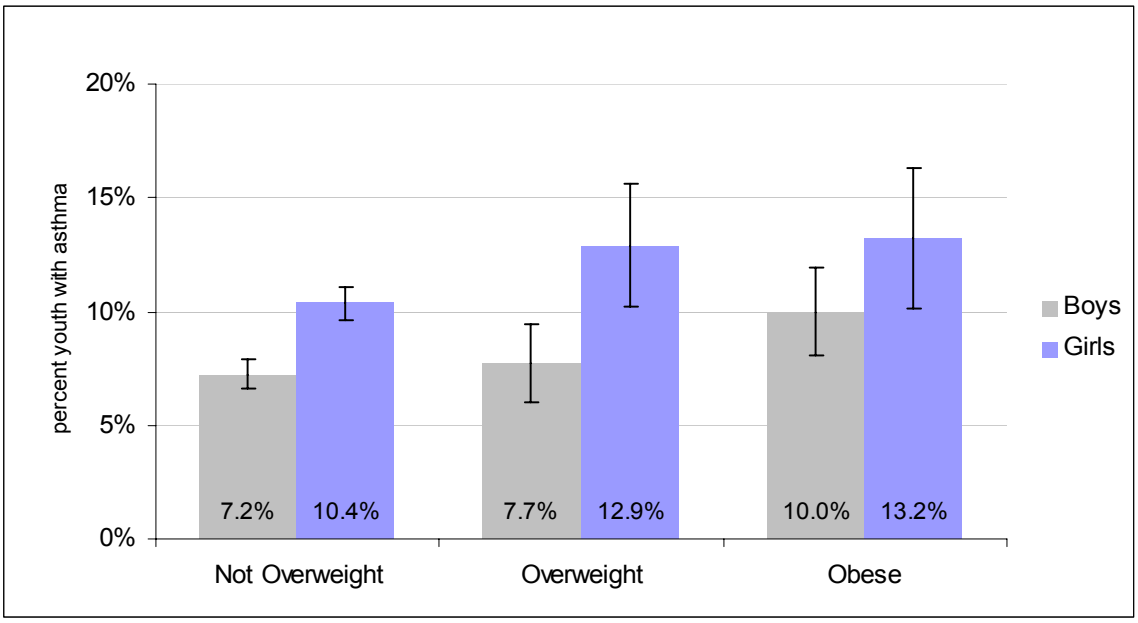
Source: 2001--03 combined Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Obesity or overweight were associated with increasing prevalence of asthma for Washington boys and girls (see Figure 47).**** This association could be explained by gender-specific factors such as small airways for boys (which might be more affected by greater body mass).

Among adults obese women had nearly double the prevalence of asthma in comparison to women who were not overweight, while among girls the difference was not as great. This might be explained by lower levels of estrogen among girls in comparison to women, if estrogen effects are associated with obesity and asthma. (see previous discussion on age and gender in Chapter IV Section A.)

**** p<.001 for grade-adjusted association between current asthma and obese (vs. overweight/not overweight) among boys; p=.02 for grade-adjusted association between current asthma and obese/overweight (vs. not overweight) among girls.

Figure 47: Asthma prevalence by bodyweight and gender, among Washington youth



Source: 2002 and 2004 combined Washington State Healthy Youth Survey (HYS), grade-standardized for 8-10-12th grade respondents.

Asthma can be triggered by exercise. The condition called exercise-induced brochospasm, or exercise-induced asthma (EIA), is caused by a narrowing of the airways leading to the lung caused by the loss of heat, water, or both from the airways during exercise. It is caused by increased ventilation and inhalation of cool, dry air compared to the air within the lungs. It is possible that some people with asthma may avoid exercise, which contributes to obesity; however, with good asthma control strategies in place (appropriate medication and avoidance of triggers, such as exercising outdoors on days with poor air quality or near high-traffic roads) people with asthma should be able to exercise.

C. Substance Abuse

Environmental exposures or occupational exposures that cause or exacerbate asthma are typically involuntary – people inhale the air around them, including harmful substances when those are present. Some people, however, may inhale chemicals purposely to produce intoxication. In addition to other dangerous effects on the body, introduction of these substances to the lungs may be associated with development or exacerbation of asthma.

The use of inhaled intoxicants (things you purposely sniff or "huff" to get high) by middle school youth is a growing concern in substance abuse prevention.[96,97] Inhaled intoxicants include adhesives (model airplane glue), solvents (nail polish remover, markers, paint thinner), aerosols (hairspray), cleaning agents (spot removers, keyboard cleaning fluids), food products (aerosol whipped cream, vegetable cooking spray), or

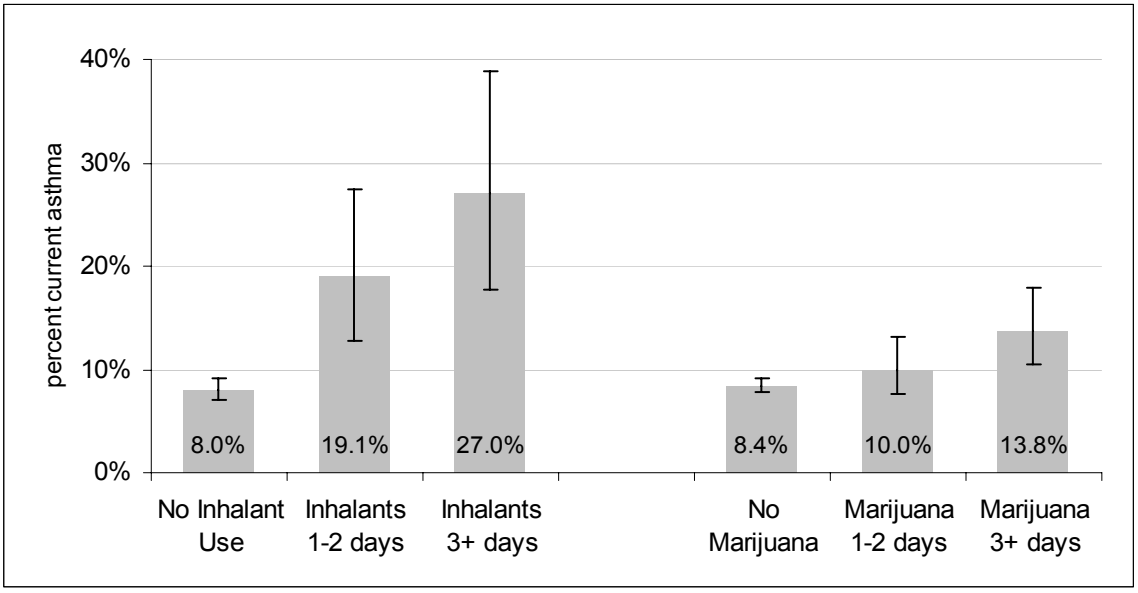
other gases (butane, propane and Freon).[98] Some of these agents may also be inhaled during normal work or home life without adequate protective equipment or ventilation, but the following discussion considers only intentional inhalation for the purpose of getting high.

Inhaled intoxicant use during the past 30 days was strongly associated with asthma prevalence among 8th graders in Washington (see Figure 48, p<.001). There was no association between inhaled intoxicant use and asthma for 10th and 12th graders, but use of inhaled intoxicants is highest among middle school youth and very low among high school-aged youth. Among 8th graders, the prevalence of asthma among those who had used inhaled intoxicants more than twice during the past month was three times greater than among youth who did not use inhalants.

Inhalant users have the highest asthma prevalence of any sub-group analyzed for this report. Because it is unlikely that the onset of asthma caused the inhalant use, it is possible that the inhalant use caused the onset of asthma in at least some cases. Clearly, inhalant use does not explain most asthma occurrence: only about ten percent of the 8th graders with current asthma reported inhalant use.

Marijuana is another intoxicant that is inhaled by young people to get high. Like cigarette smoking, marijuana use increases with age. There was no association between marijuana use and asthma for high school-aged youth, but for Washington 8th graders progressively greater use of marijuana was associated with increased prevalence of asthma (p=.001).

Figure 48: Asthma prevalence by past-month inhaled substance use frequency, among Washington youth (8th grade)



Source: 2002 Washington State Healthy Youth Survey (HYS) for inhalants; 2002 and 2004 HYS combined for marijuana, 8th grade only.

As with cigarette smoking, use of inhaled intoxicants and marijuana was associated with increased asthma prevalence for middle school grades only. These associations may be

related to common risk factors (unstructured family environments, parental smoking or drug use), but regardless of these factors, use of any concentrated intoxicant in fumes or smoke is likely to aggravate asthma conditions and should be considered when managing youth with asthma.

D. Allergies

Allergies and asthma are highly inter-related. An allergy is an exaggerated immune response or reaction to some substance that is not generally harmful, while asthma is a inflammatory reaction only within the airways that can be triggered by exposure to a specific substance, but also by conditions such as change in temperature, exercise, or stress. Common allergens include pollen, mold spores, animal dander from feathered or furry animals, dust mites (a major component of house dust in humid climates) and cockroaches. These substances can also be asthma triggers (see discussion in Chapter VII). On contact with the allergen, the allergic person's body produces chemicals that result in allergy symptoms such as itchy eyes, runny nose, skin problems (Eczema) and/or a rash. These symptoms irritate the inflamed airways and lead to asthma symptoms.

Washington data are not available to describe the proportion of people with allergies, or allergies and asthma. National studies indicate that among adults, including older adults, between 60-75% of people with asthma were also atopic (demonstrated allergic reactions by skin test or in vitro test).[99,100,101]

E. Genetics

If a person has a parent with asthma, he or she is three to six times more likely to develop asthma than is a person who does not have a parent with asthma.[1] Data from Washington are not currently available to describe the proportion of people who have genetic risk factors for asthma; however advances in human genetics related to asthma are expected to provide better information about the contribution of genetic variation to the development of disease when people are exposed to certain environmental factors and variation in individual response to therapy. The use of this genetic information will improve targeted disease prevention and health management strategies for respiratory diseases. One possible application could be testing of newborns to identify infants who might benefit from environmental modifications or immunotherapy for prevention.[102]

VI. Clinical Asthma Control

Most of the life disruption caused by asthma could be avoided if people with asthma and their healthcare providers managed the disease according to established guidelines. Effective asthma control reduces the need for hospitalizations and urgent care visits (in either an emergency department or physician's office) and enables patients to enjoy normal activities.[103,104] Asthma control could also reduce the significant cost of hospital care for asthma, compared to the more frequently used and less costly outpatient and pharmaceutical services. As discussed earlier (see Figure 5) single individuals can contribute substantially to the healthcare system burden through multiple urgent care visits, thus careful asthma control for even a small number of people with asthma might have substantial benefits.

Effective control of asthma includes four components: avoiding or controlling the factors that may make asthma worse (for example, environmental and occupational allergens and irritants), taking appropriate medications tailored to the severity of the disease, objective monitoring of the disease by the patient and the healthcare professional, and actively involving people with asthma in managing their own disease. [105] This chapter discusses disease management components that involve a healthcare provider. The next chapter (Chapter VII) discusses environmental and self-management of exposures.

A. Classifying Asthma

The severity of asthma can be classified based on symptoms and lung function. Public health surveillance data do not include estimates of an individual's lung function, however severity can be estimated using information about symptoms.[106] These classifications are based on criteria described by the National Heart, Lung and Blood Institute (see Table 1).[107]

Although this classification system is convenient, it is likely to substantially underestimate true asthma severity and burden of disease for the individual, and thus should be interpreted somewhat cautiously.[108] Individuals classified with greatest symptom severity may either have clinically severe asthma that is resistant to therapy, or have asthma that is poorly controlled (insufficient or ineffective clinical strategies, or continued exposure to environmental triggers). Individuals classified with lesser symptom severity may in fact have clinically more severe asthma that is well-controlled.

Questions about frequency of symptoms and frequency of sleep interruption as a result of symptoms were included in the 2001 BRFSS (for adults) and the 2004 HYS (for youth in 8th, 10th, 12th grades). Results from the specific questions were presented in Chapter II.

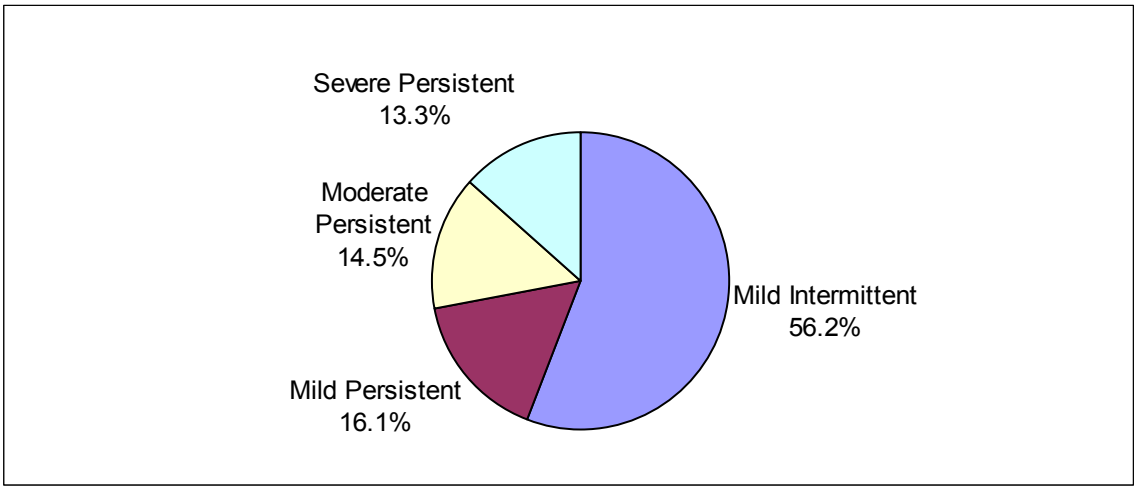
Table 1: Asthma symptom severity classifications

Severity Classification	Symptoms	Nighttime Symptoms	Lung Function
Step 4: Severe Persistent	• Continual symptoms • Limited physical activity • Frequent exacerbations	Frequent	• FEV_1 or PEF ≤60% predicted • PEF variability > 30%
Step 3: Moderate Persistent	• Daily symptoms • Daily use of inhaled short-acting $beta_2$-agonist • Exacerbations after activity • Exacerbations ≥2 times a week; may last days	>1 time a week	• FEV_1 or PEF >60%-<80% predicted • PEF variability > 30%
Step 2: Mild Persistent	• Symptoms >2 times a week but <1 time per day • Exacerbations may affect activity	>2 times a month	• FEV_1 or PEF ≥80% predicted • PEF variability 20-30%
Step 1: Mild Intermittent	• Symptoms ≤2 times a week • Asymptomatic and normal PEF between exacerbations • Exacerbations brief (from a few hours to a few days); intensity may vary	≤2 times a month	• FEV_1 or PEF ≥80% predicted • PEF variability <20%

Classifications based on criteria described by the National Heart, Lung and Blood Institute [109]
FEV_1=forced expiratory volume in one second, the volume of air exhaled after a maximum inspiration; PEF = peak expiratory flow, the speed of exhale with the greatest effort possible.

Using the symptom severity classification described above, more than half of Washington adults with current asthma can be described as having "mild intermittent" symptoms, and approximately equal shares of adults have "mild persistent", "moderate persistent", and "severe persistent" asthma symptom severity.

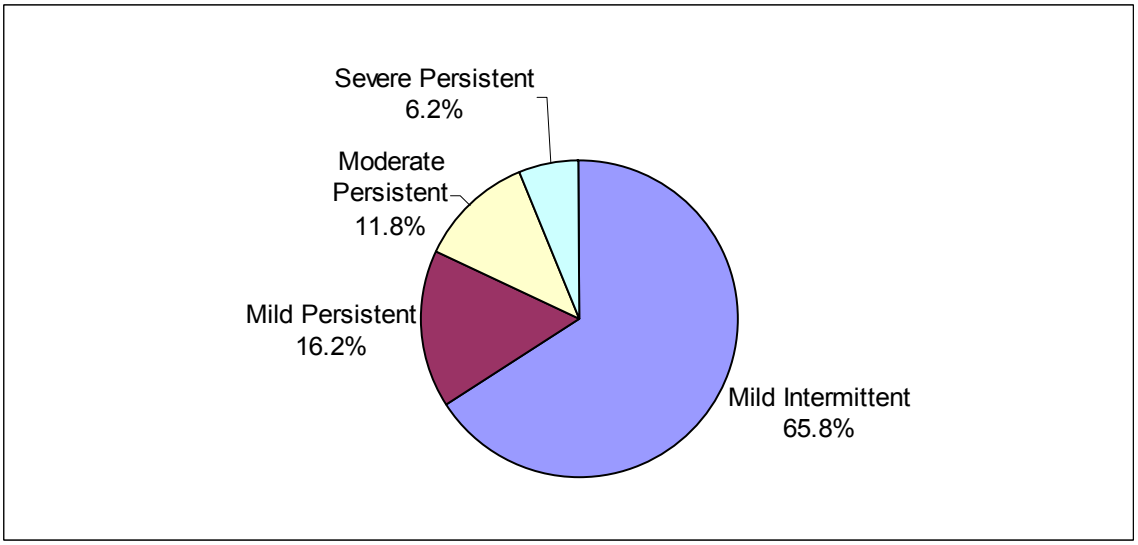
Figure 49: Distribution of asthma symptom severity among Washington adults with current asthma



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

Among youth with current asthma, about two-thirds can be classified as having "mild intermittent" symptom severity, and fewer than one in ten have "severe persistent" asthma symptom severity.

Figure 50: Distribution of asthma symptom severity among Washington youth with current asthma

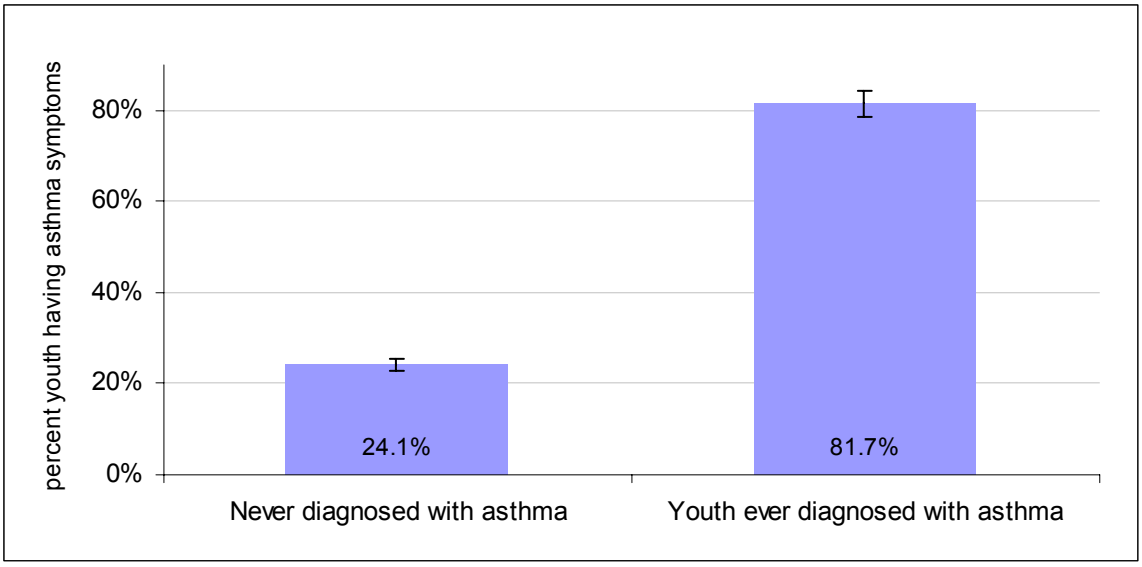


Source: 2004 Washington State Healthy Youth Survey (HYS), combined results for 8th-10th-12th grade students

Direct comparison of youth and adult asthma symptom severity, and apparent differences in distributions of severity, may be related to youth not understanding or inaccurately reporting on questions about their symptoms. Differences may also be the result of under-diagnosis of asthma or recently developed clinical asthma that has not yet been diagnosed.

As discussed previously related to the definition of asthma (Chapter III, Section A), adult telephone surveys "skip" additional questions specific to asthma if respondents do not have asthma. Paper-based youth survey questionnaires that do not utilize "skip patterns" (the HYS does not) mean that youth must respond to all questions. In the 2004 HYS, youth were specifically directed to respond to a question about whether they had asthma symptoms *regardless of whether they had been diagnosed with asthma by a healthcare professional.* Among youth who had never been diagnosed with asthma, about one in four indicated that they had asthma symptoms (cough, wheezing, shortness of breath, chest tightness and phlegm production when a person does not have a cold or respiratory infection) during the past month (see Figure 51). The self-report of asthma symptoms without a diagnosis of asthma could be at least partly due to undiagnosed asthma in the youth population.

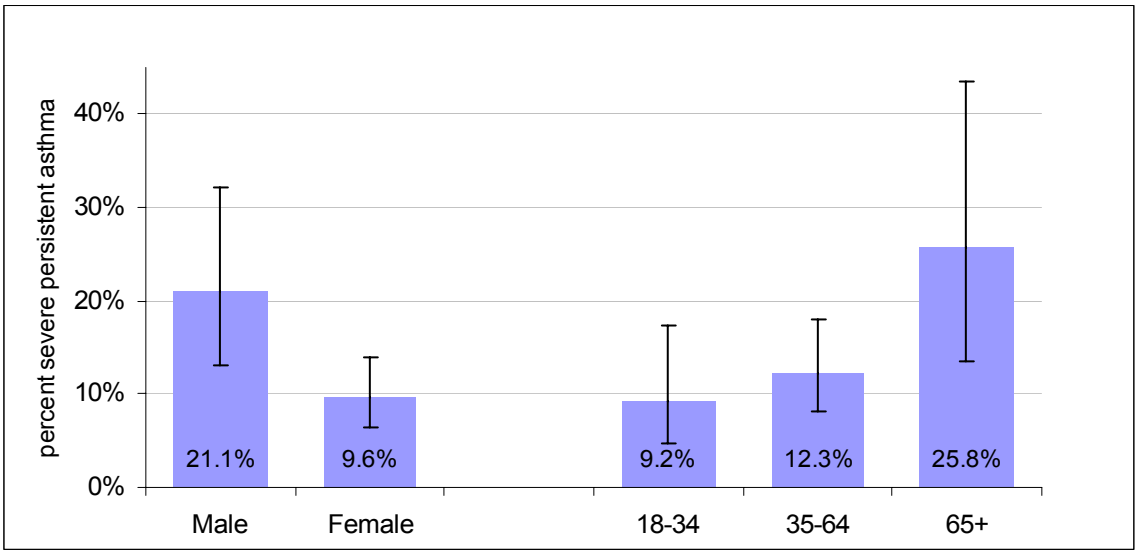
Figure 51: Prevalence of asthma symptoms by lifetime asthma status among Washington youth



Source: 2004 Washington State Healthy Youth Survey (HYS), combined results for 8th-10th-12th grade students

Previous discussion (Chapter IV, Section A) indicated that adult hospitalization rates differ by age and gender: females have higher rates than males, and the oldest adult age groups have higher rates than younger age groups. Similar to hospitalization and death rates, "severe persistent" symptoms among adults with asthma appear to increase with age and are highest among adults age 65 and older (see Figure 52, p=.04 for trend). In contrast to hospitalization and death rates, which were consistently higher for females, females were less than half as likely as males to report "severe persistent" symptom severity (p=.01). This could be explained by either under-reporting of severe symptoms by females (which seems unlikely), or, more likely, under-reporting of current asthma by male adults, resulting from minimization of mild symptoms by males.

Figure 52: Prevalence of severe persistent symptom severity by age and gender among Washington adults with asthma

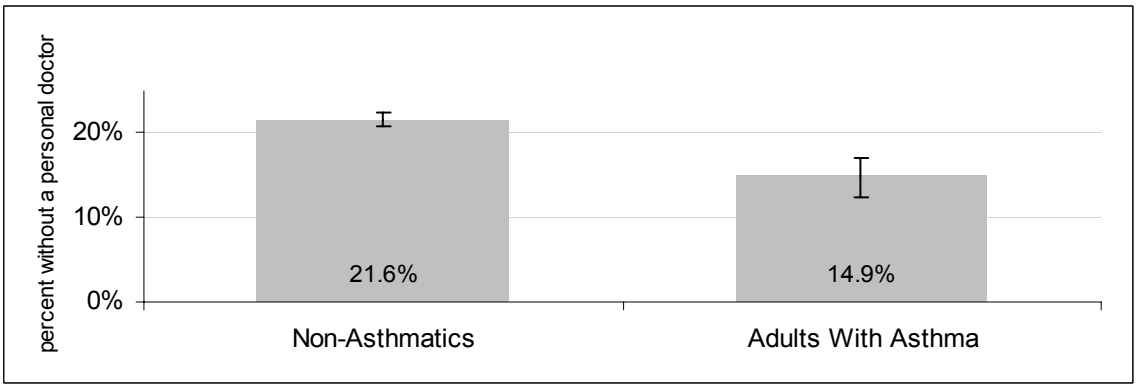


Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

B. Access to Healthcare

Effective clinical management of asthma relies first upon access to a healthcare provider. Fewer adults with asthma than adults without asthma reported not having a personal doctor (see Figure 53, $p<.001$). This suggests that most people with asthma have identified a place to go for their healthcare needs. However, these numbers also mean that almost 60,000 Washington adults with asthma lack an identified personal healthcare provider.

Figure 53: Prevalence of not having a personal doctor by asthma status, among Washington adults

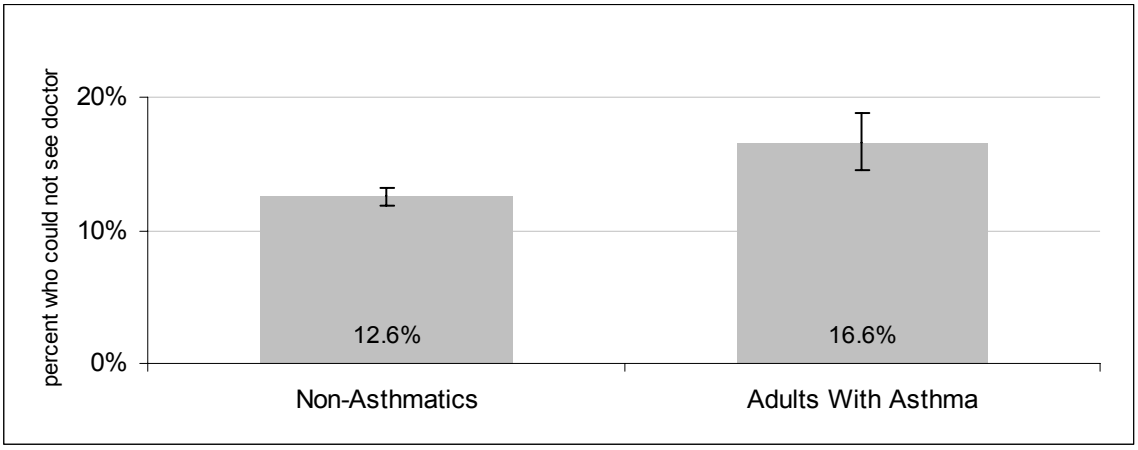


Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

Visiting a healthcare provider may be prevented by various factors such as travel, financial, or psychological barriers. Because asthma is associated with lower income, it is important to acknowledge that although an individual may have a healthcare provider,

they may not be able to access that provider as often as desired due to lack of money. Adults with asthma were more likely than adults without asthma to report being unable to see a doctor during the past year because of the cost (see Figure 54, p<.001).

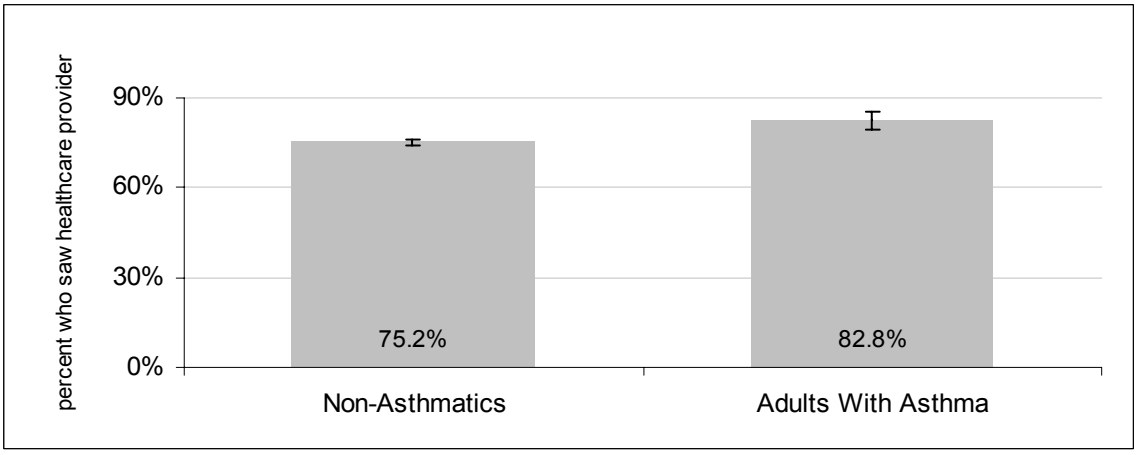
Figure 54: Prevalence of unmet healthcare needs by asthma status, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Most Washington adults visited a healthcare provider during the previous year for a routine checkup (see Figure 55, p<.001). Although people with asthma had been more likely to report not being able to see a doctor when they needed care because of money, they were also more likely than adults without asthma to have actually visited a doctor for a routine checkup (for any reason).

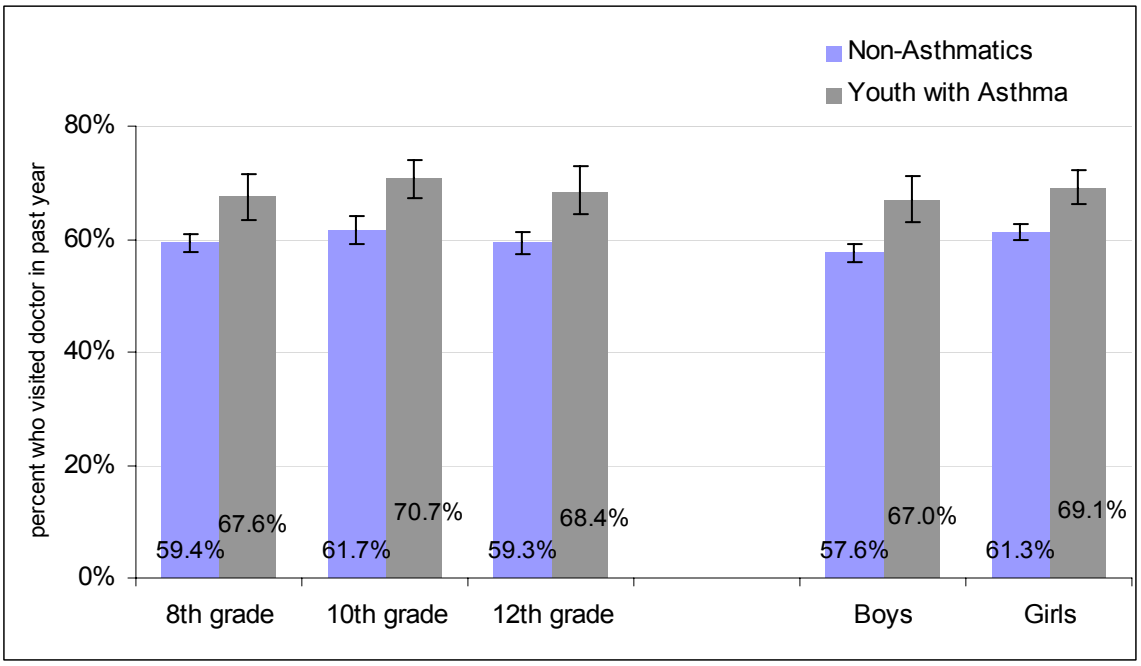
Figure 55: Prevalence of past-year routine healthcare visit (any reason) by asthma status, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

As with adults, youth with asthma were more likely than youth without asthma to have seen a healthcare provider during the previous year for a checkup, regardless of grade or gender (p<.001). Boys were less likely than girls (with or without asthma) to have seen a healthcare provider for a checkup during the previous year (p<.001).

Figure 56: Prevalence of past-year routine healthcare visit (any reason) by grade or gender and asthma status, among Washington youth

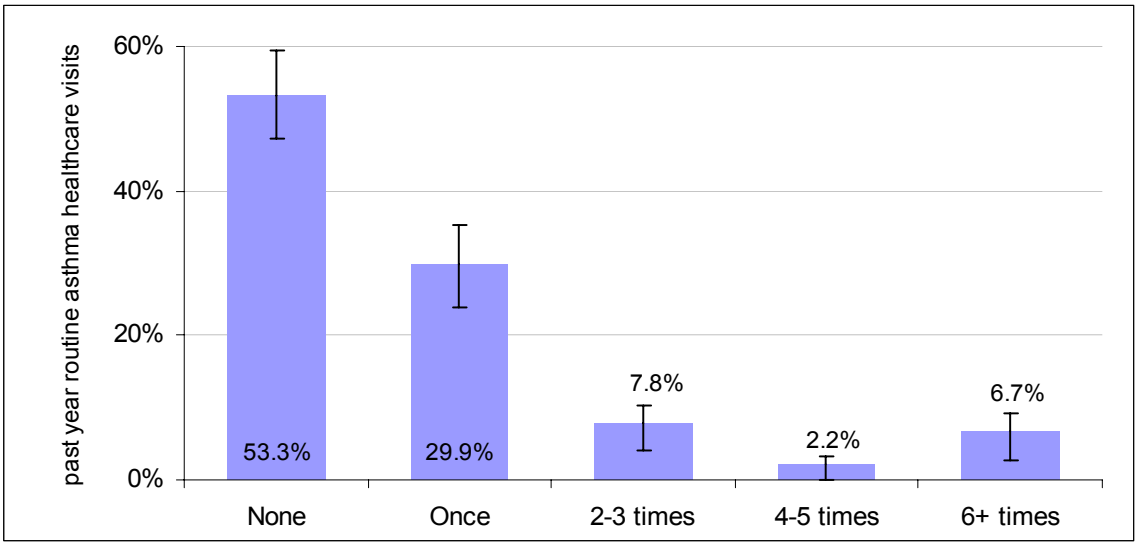


Source: 2002 and 2004 combined Washington State Healthy Youth Survey (HYS), grade-standardized for boy/girl estimates.

The previously discussed associations (see Chapter V, Section C) for youth asthma with inhaled intoxicant use, marijuana use, depression and suicidal thoughts indicate that youth presenting with asthma may benefit from comprehensive support strategies.

People with asthma were specifically asked about the last time they visited their healthcare provider as part of a routine visit for asthma control (that is, not in response to an acute episode or as part of a different visit). About half of adults with asthma reported that they had seen a healthcare provider during the previous year for this reason, and most (30%) visited only once (see Figure 57).

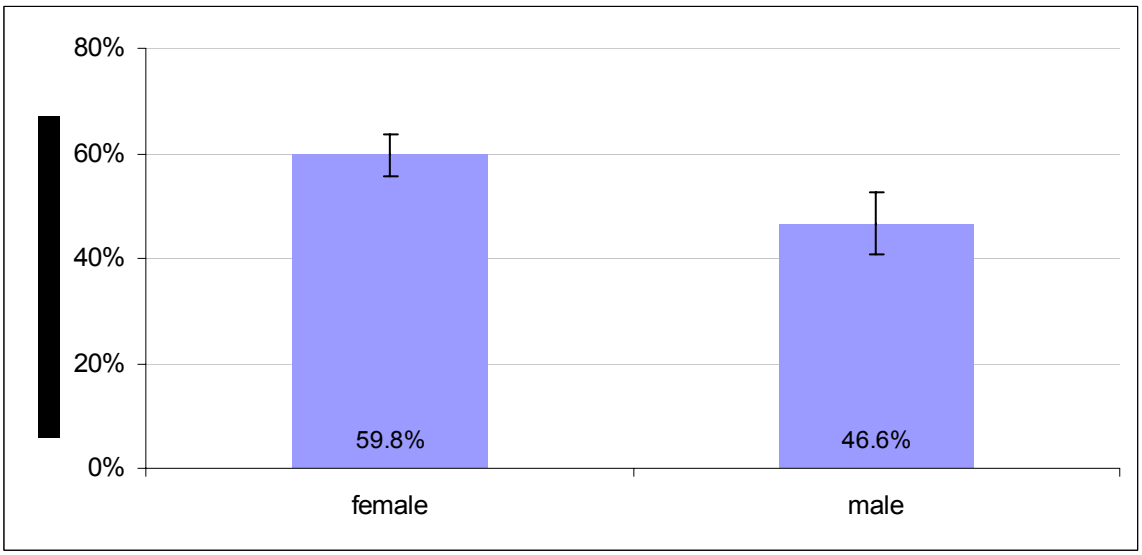
Figure 57: Distribution of past-year routine asthma healthcare visit frequency among Washington adults with asthma



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

Washington youth with asthma were also asked whether they had visited a healthcare provider during the previous year for a routine asthma visit. About half of youth overall with asthma had visited a doctor for an asthma checkup in the previous year (see Figure 58). There were not differences by grade, but boys with asthma were less likely than girls to report having a routine asthma visit ($p<.001$).

Figure 58: Distribution of past-year routine asthma healthcare visits by gender, among Washington youth with asthma



Source: 2004 Washington State Healthy Youth Survey (HYS), combined results for 8th-10th-12th grade students.

C. Quality of Asthma Healthcare

Beyond assuring that people with asthma have access to any care, assuring good quality of care is essential. This means that the healthcare provider follows research-based clinical guidelines for treating and managing asthma. Guidelines have been described as part of Healthy People 2010 Objectives, although targets for achieving those objectives have not been established.

Healthy People 2010 Objective 24-7
Increase the proportion of people with asthma who receive appropriate asthma care according to National Asthma Education and Prevention Program (NAEPP) Guidelines.

a. People with asthma receive written asthma management plans from their healthcare provider.
b. People with asthma with prescribed inhalers receive instruction on how to use them properly.
c. People with asthma receive education about recognizing early signs and symptoms of asthma episodes and how to respond appropriately, including instruction on peak flow monitoring for those who use daily therapy.
d. People with asthma receive medication regimens that prevent the need for more than one canister of short-acting inhaled beta agonists per month for relief of symptoms.
e. People with asthma receive follow-up medical care for long-term management of asthma after any hospitalization due to asthma.
f. People with asthma receive assistance with assessing and reducing exposure to environmental risk factors in their home, school, and work environments.

(Targets not established)

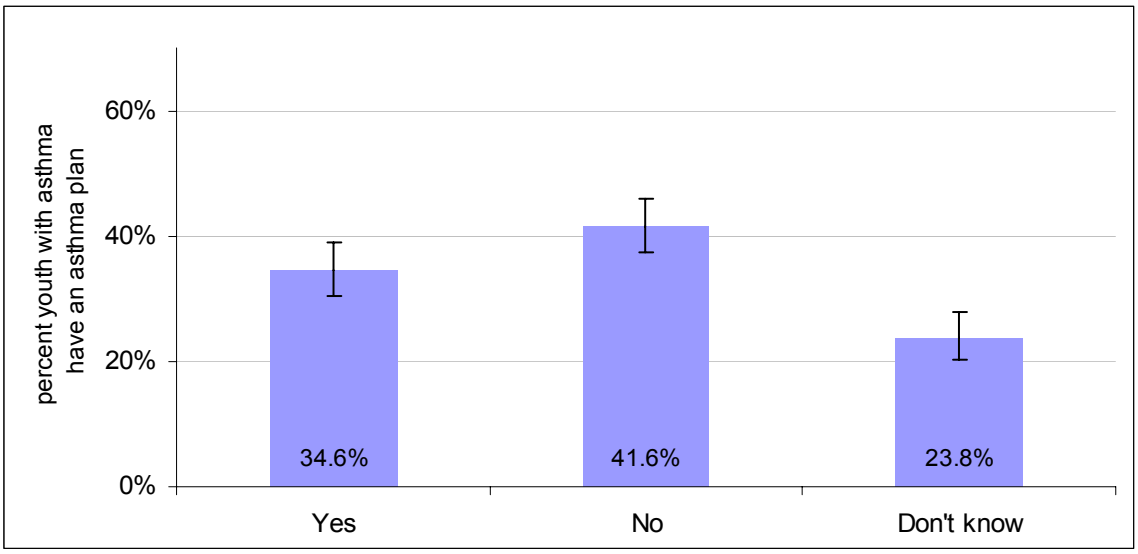
Written Asthma Management/Action Plans

Part of the guidelines for care cited above is receiving a written asthma management/action plan from a healthcare provider. Data for adults are not available, but youth were asked whether they had ever received a written asthma plan from their healthcare provider.

About one-third of youth with asthma had received a written asthma management/action plan from their healthcare provider (see Figure 59). An additional 24% did not know whether they had received a plan, but as the purpose of the plan is to provide instruction about pharmaceutical and self-management strategies, the plan can only be considered effective if the youth are aware of it. There were no differences by grade or gender for receiving a written asthma management/action plan.

This question asks about "ever" receiving an asthma plan, and it is important that asthma plans are kept current. Asthma management/action plans may need updating as symptoms change over time, particularly for youth, among whom clinical expression of asthma may change with the onset of puberty.

Figure 59: Prevalence of ever having a written "asthma plan," among Washington youth with asthma



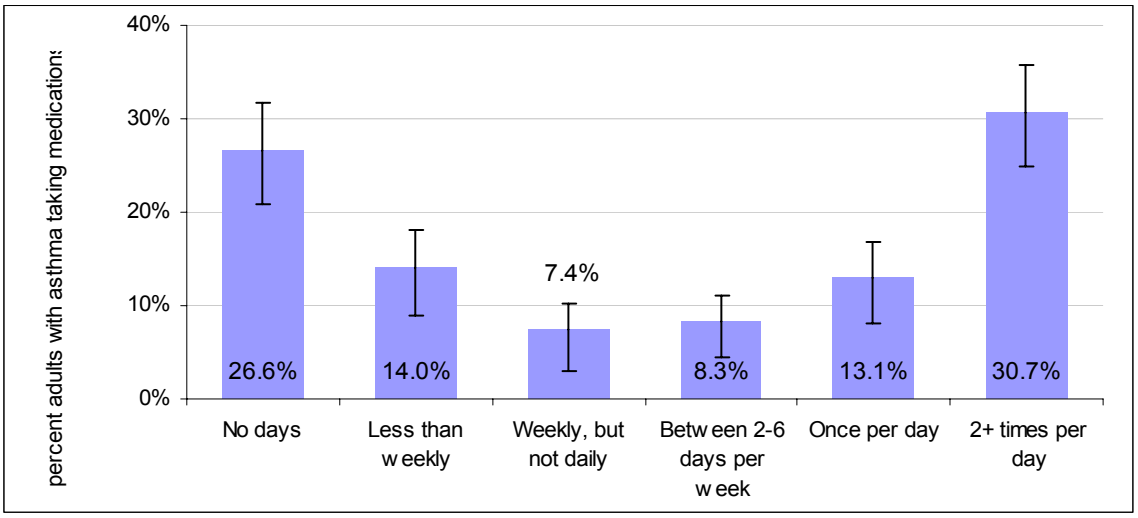
Source: 2004 Washington State Healthy Youth Survey (HYS), combined results for 8th-10th-12th grade students.

Asthma Medications

Medications are administered with the primary goal of prevention asthma attacks for people with asthma. Medicine for asthma is different for each person. It can be inhaled or taken as a pill and comes in two types—quick-relief ("rescue" medication, typically an inhaler) and long-term control. Long-term control medicines are usually used daily to reduce the frequency and severity of asthma attacks, but they are not effective during an attack.[1] Quick-relief medicines control the symptoms of an asthma attack, and a goal of good asthma control is to use them only rarely. If a person with asthma is using quick-relief medicines more and more, this indicates inadequate control strategies and a need to change the control medications and/or the asthma management/action plan.

About 73% of Washington adults with asthma reported taking some form of medicine for their asthma in the past month, including both control and rescue medications (see Figure 60). About 44% of people with asthma take asthma medication every day, with nearly one-third taking asthma medication two or more times per day.

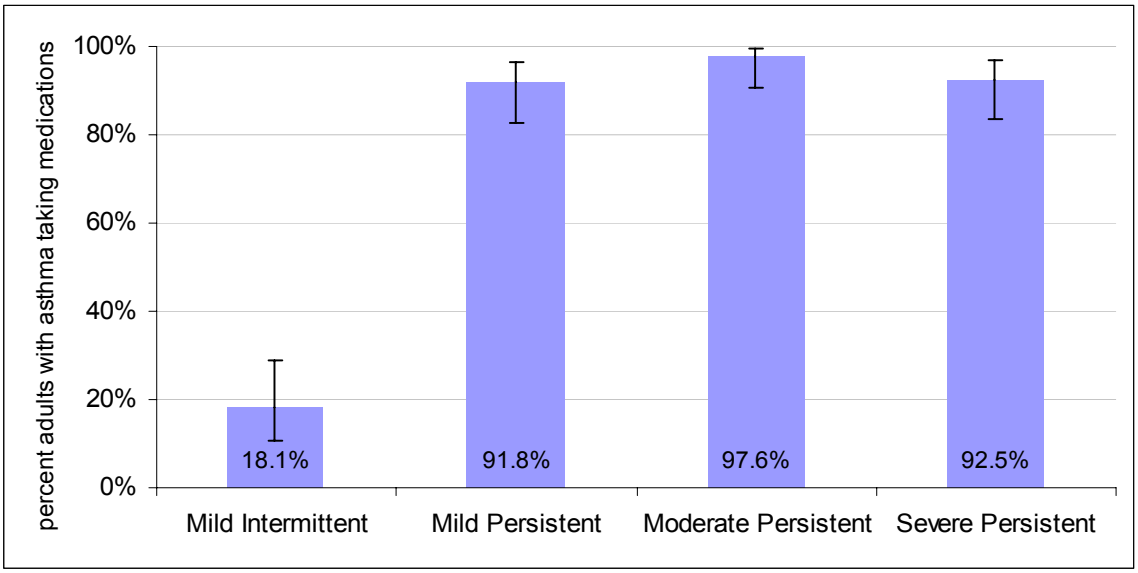
Figure 60: Distribution of asthma medication use frequency during past month, among Washington adults with asthma



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS). [Note: Some people who take asthma medication less often than every month may be counted in the "No days" category.]

Not all people with asthma require medications to control their symptoms. Adults were stratified by their symptom severity to identify what proportion were taking medications of any type (note that this would include both "control" and "rescue" medications). Only about one in five adults with mild intermittent asthma reported taking medications for asthma (see Figure 61). More than 90% of adults with each category of persistent asthma reported taking medications for their asthma in the prior month. All adults with persistent asthma, particularly moderate to severe persistent asthma, should have some type of medications available. Lack of medical coverage or barriers to utilization of healthcare may be reasons why people with asthma do not have needed medications.

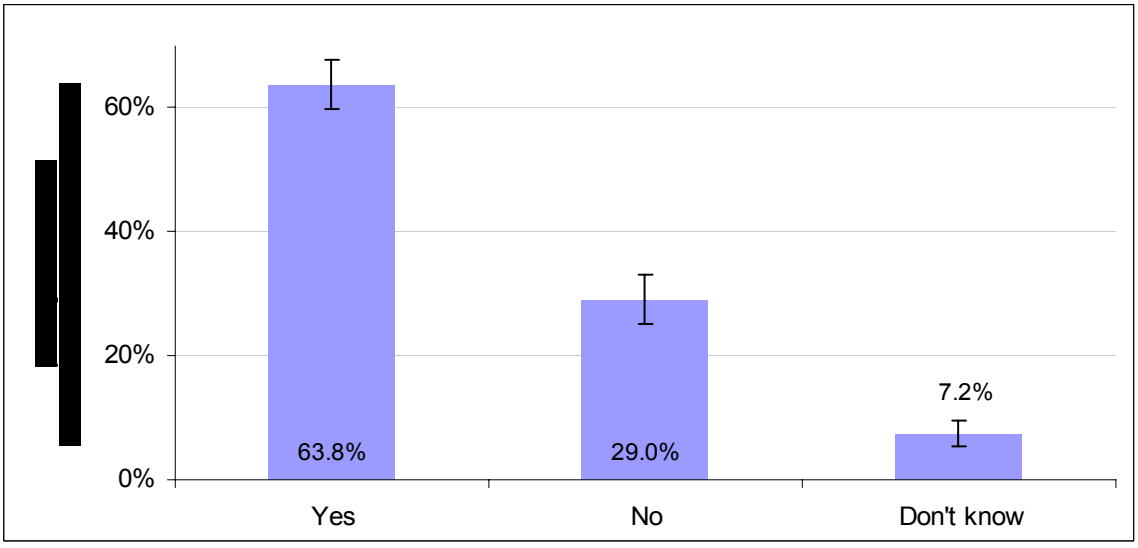
Figure 61: Prevalence of asthma medication use during past month by symptom severity, among Washington adults with asthma



Source: 2001 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Among youth with any type of asthma, nearly two-thirds reported taking daily preventive medication for their asthma during the past year (see Figure 62). Preventive medication is different than "rescue" medications taken during an asthma attack; the adult question about use of medication did not distinguish between preventive and rescue medication. There were no differences for taking asthma medication by grade or gender.

Figure 62: Prevalence of daily preventive asthma medication use during past year, among Washington youth with asthma



Source: 2004 Washington State Healthy Youth Survey (HYS), combined results for 8th-10th-12th grade students.

Patient Education

Washington has not assessed the proportion of people with asthma who receive formal patient education to manage their asthma, but this is a recommended component of good asthma care (see HP2010 Objective 24-6 in box for components of care). A national survey showed that only 8.4% of persons with asthma received formal patient education in 1998.[110]

Healthy People 2010 Objective 24-6
Increase the proportion of people with asthma who receive formal patient education, including information about community and self-help resources, as an essential part of the management of their condition.
Target:

- 30% or more of people with asthma*

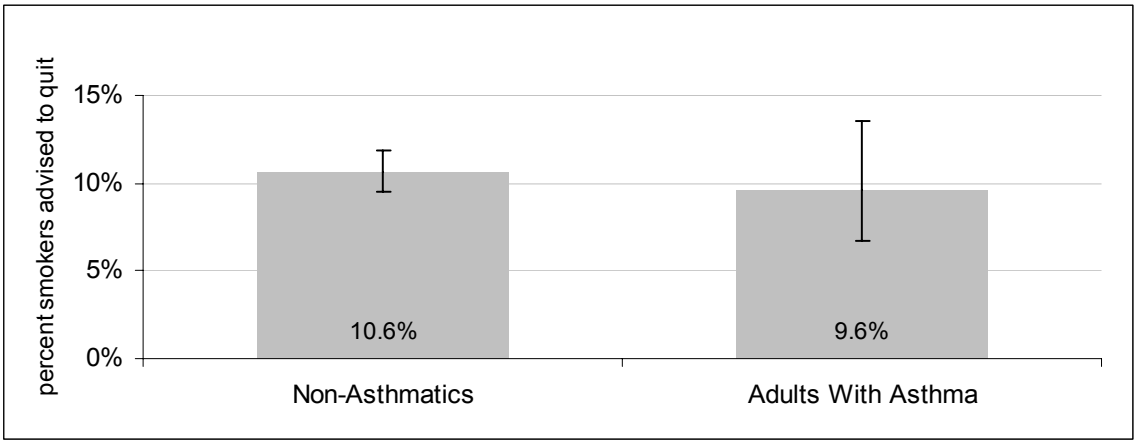
* age-adjusted to year 2000 standard population

Smoking Interventions

As described previously (Chapter V, Section A), smoking is common among people with asthma. Research suggests that smoking cessation reduces asthma severity,[77] and thus, all smokers with asthma should be highly encouraged to quit and to maintain successful quitting. An important component of the National Asthma Expert Panel Paper (NAEPP) clinical guidelines for treatment and control of asthma is for physicians to advise patients with asthma who smoke to quit.

Washington adults with asthma did not, however, report more advice to quit smoking from a healthcare provider in comparison to people without asthma (see Figure 63), despite more use of healthcare. Overall, about one in ten smokers – regardless of asthma status – reported receiving advice to quit from a healthcare provider during the previous year, suggesting that more work remains to promote smoking interventions with all patients in healthcare settings.

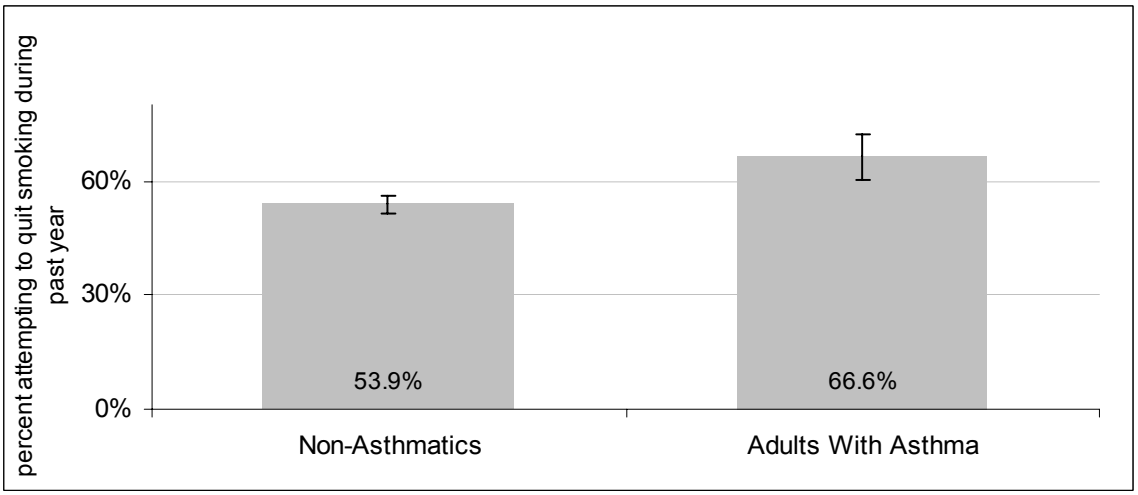
Figure 63: Prevalence of receiving advice to quit smoking during the past year by asthma status, among Washington adult smokers



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS). non-significant difference.

Washington data indicate that smokers with asthma were more likely to have tried to quit during the previous year than people without asthma (see Figure 64, $p<.001$).This suggests that people with asthma who smoke are more motivated to quit than the general population of smokers, and could be receptive to advice or support for quitting offered by a healthcare provider.

Figure 64: Prevalence of past-year quit attempts by asthma status, among Washington adult smokers



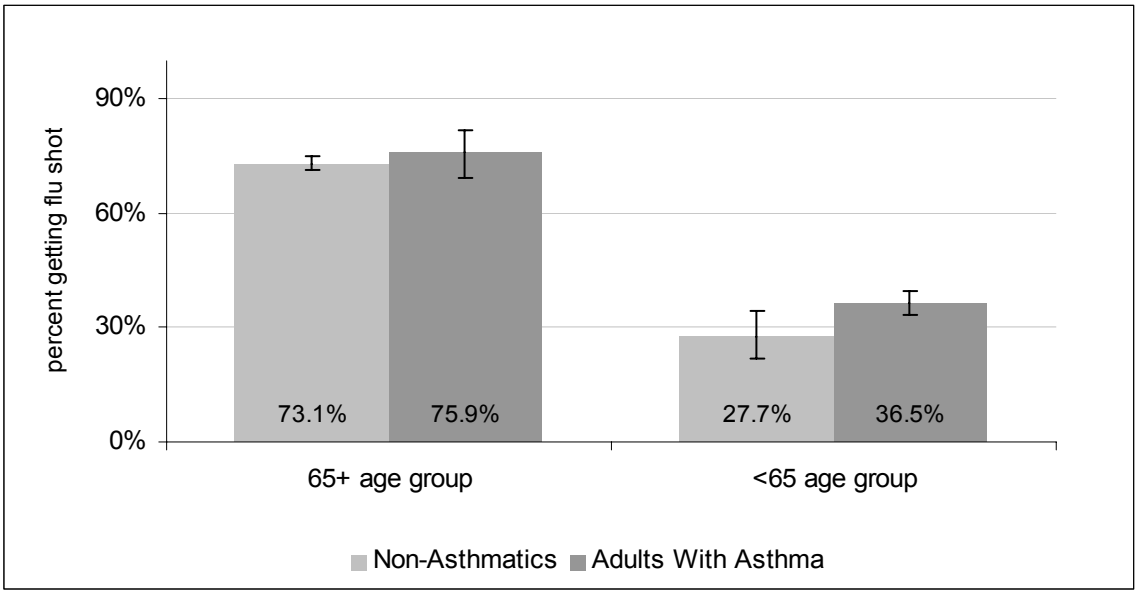
Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Preventive Vaccines

Another specific element of the NAEPP clinical practice guidelines for control of asthma is that people with asthma should receive preventive vaccines for respiratory conditions such as flu and pneumonia. Most seniors (age 65 and older) are encouraged to get a flu shot regardless of their asthma status.

Flu vaccines are generally given annually. Among seniors, people with asthma and people without asthma were similarly likely to have received a flu vaccine during the past year (see Figure 65). Among people younger than 65, those with asthma were significantly more likely to have gotten a flu shot during the past year than those without asthma ($p<.001$).

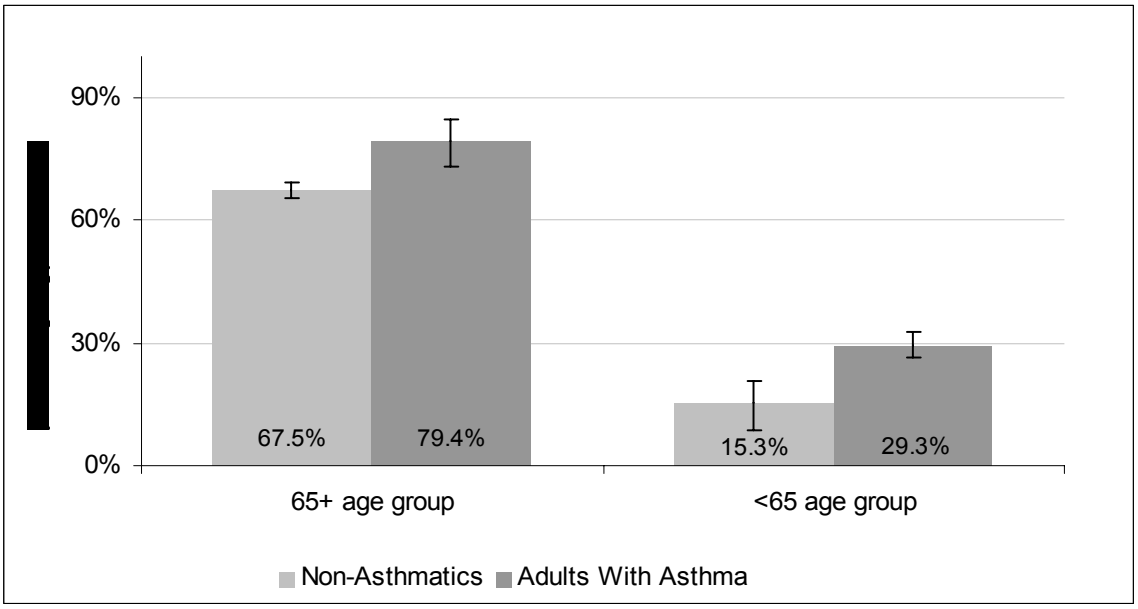
Figure 65: Prevalence of receiving preventive flu vaccines during the past year by age and asthma status, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Pneumonia vaccine is generally given only once. All seniors are advised to get a pneumonia vaccine to prevent disease. Both seniors and younger adults with asthma were more likely than adults without asthma to have ever had a pneumonia shot (see Figure 66, $p<.001$ for both <65 and 65+ age groups).

Figure 66: Prevalence of ever receiving preventive pneumonia vaccine by age and asthma status, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Discussion

Survey data show that quality of health care could be improved. Although clinicians seem to be appropriately targeting people with asthma for receipt of pneumonia vaccine among the elderly, there are missed opportunities. Data for youth show substantial under-utilization of written care plans. Most notably, people with asthma who smoke, who seem motivated to quit, are not well targeted by clinicians for smoking cessation assistance.

D. Association with Other Chronic Disease

Asthma is strongly associated with other types of chronic disease. This means that people with asthma may require treatment not only for asthma, but also for associated conditions. For example, people who have been hospitalized for asthma also have an increased risk of subsequent death from chronic obstructive pulmonary disease (COPD) and cardiovascular disease, and research suggests that these patients require as much attention for their co-morbidity as their asthma.[5]

It is not always clear whether asthma contributes to other conditions, whether other conditions contribute to asthma, or whether both conditions are related to common underlying risk factors (such as smoking). However, regardless of causal mechanisms, healthcare providers should be aware that patients presenting with asthma may have other chronic conditions and comprehensively examine the health of a patient. This includes monitoring multiple (potentially competing) medical therapies, and being aware that patients themselves may be confused by conflicting recommendations when attempting to manage multiple health conditions. For example, patients advised to avoid walking outdoors on days with poor air quality and to avoid high-traffic areas as part of their asthma management plan may be conflicted or simply confused when a different provider

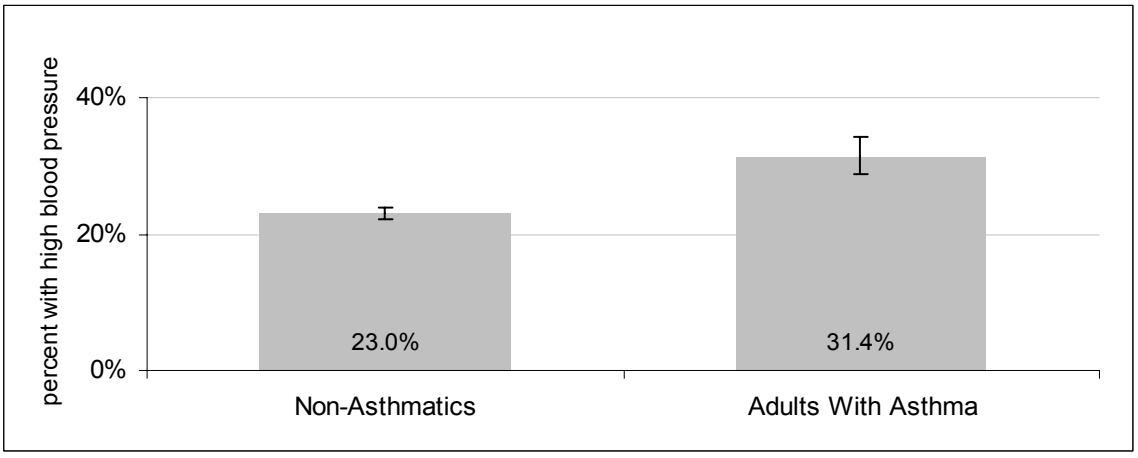
advises them to walk outdoors in order to control weight. Washington data were available to describe associations between asthma and heart disease and diabetes, leading causes of death in Washington.

As noted earlier in this report, adults and youth with asthma report higher rates of depression than do those without asthma. Youth with asthma also reported higher rates of suicide ideation and substance abuse. Healthcare providers should assess for these factors as appropriate.

Cardiovascular Disease

Heart disease is the leading cause of death and stroke is the third leading cause of death among Washington residents.[111] In Washington, the prevalence of hypertension (a predictor of cardiovascular disease) was nearly 20 percentage points greater among people with asthma than people without asthma (see Figure 67, p<.001).

Figure 67: Prevalence of hypertension by asthma status, among Washington adults

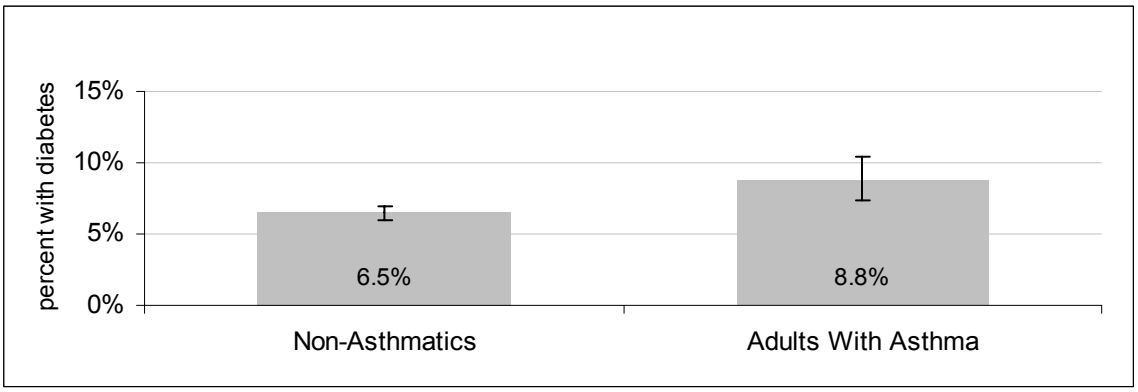


Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Diabetes

Diabetes was the seventh leading cause of death among Washington residents in 2002.[111] About 7% of Washington adult residents overall have had a doctor's diagnosis of diabetes. Diabetes prevalence was higher among people with asthma than among people without asthma in Washington (see Figure 68, p=.001).

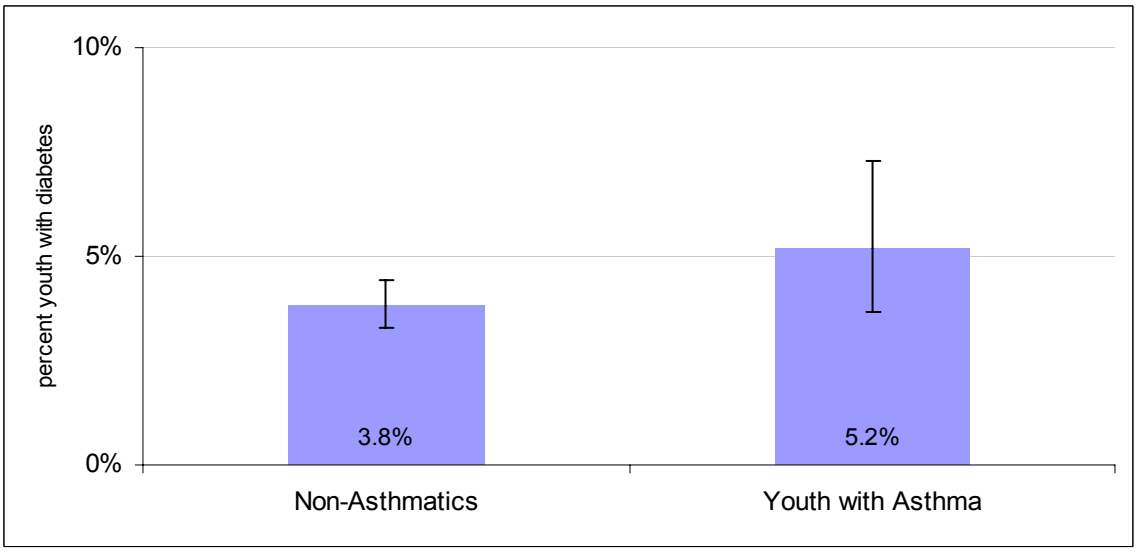
Figure 68: Prevalence of diabetes by asthma status, among Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

Youth with asthma were also more likely to have been diagnosed with diabetes than youth who did not have asthma (see Figure 69, p=.05).

Figure 69: Prevalence of diabetes by asthma status, among Washington youth



Source: 2004 Washington State Healthy Youth Survey (HYS), combined results for 8th-10th-12th grade students.

Discussion

People with asthma are more likely than people without asthma to also have hypertension, diabetes and depression. Healthcare providers should target assessment of patients with asthma for these other chronic conditions.

E. School-based Asthma Management for Youth

Management of children with asthma in school settings is critical, because youth spend a great deal of their time in schools and youth (particularly younger children) may be unable to self-manage their symptoms and environments. Schools are therefore an important partner to implement care plans that help youth control their asthma while staying involved in school activities.

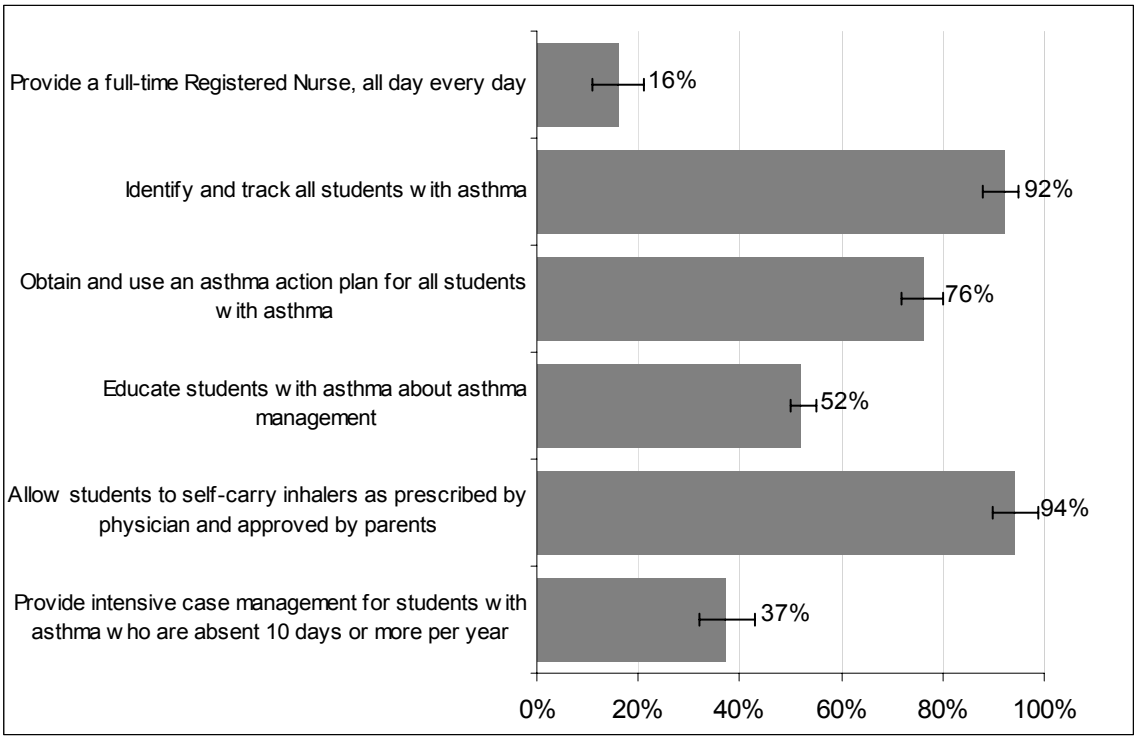
Youth with asthma report higher rates of depression and suicidal ideation than youth without asthma. Asthma among younger youth is also associated with use of cigarettes, inhaled intoxicants and marijuana. School nurses and other school staff should assess for these factors and provide comprehensive support for youth with asthma as appropriate.

Rules, Resources and Procedures

In 2004 a survey of middle and high school principals asked about rules, resources and procedures that relate to management of students with asthma (see Figure 70). No data are available for elementary school settings.

Fewer than one in five school principals reported having a full-time registered nurse at school all day and every day. Typically, in school settings nurses are only available on a part-time basis, with ongoing healthcare support provided by staff without a professional nursing license.

Figure 70: Prevalence of asthma-related policies and practices, among Washington State secondary schools



Source: 2004 Washington State School Health Education Profile (SHEP). [Note: Percentages are of schools, not students.]

Most principals reported that their schools identify and track students with asthma (92%). This was a significant improvement from 86% who reported doing so in 2002. Seventy-six percent reported creating and using asthma action plans for those students identified with asthma, a significant improvement from 62% in 2002.

About half of principals reported educating students with asthma about asthma management, and most (94%) reported allowing students to self-carry their inhalers ("rescue" medication) if approved by the physician and parents. About one-third (37%) reported providing intensive case management when students with asthma were absent ten or more days per year; in Chapter 2 of this report data were presented suggesting that about one in ten youth with asthma missed more than ten days of school per year.

Principals in more than 90% of schools reported that they provided modified physical education alternatives for students when indicated in their asthma action plan (data not shown). Youth who reported having asthma in the Healthy Youth Survey did not report different levels of exercise or fewer days of Physical Education than youth without asthma.

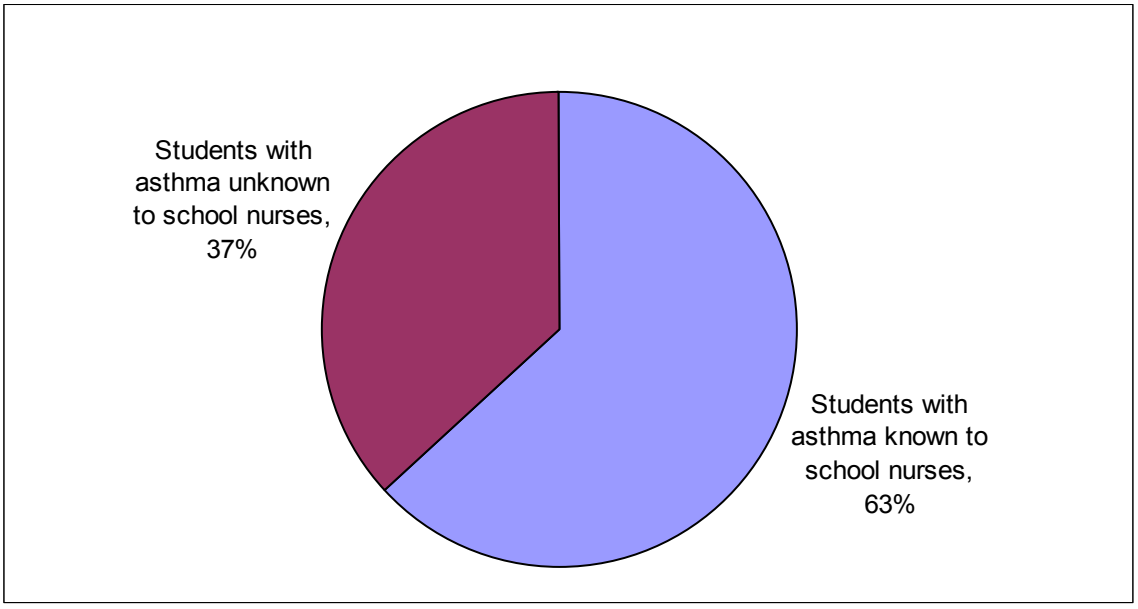
School Nurse Support

School nurses provide support services to students with a variety of health conditions. Typically, parents are asked to provide information at the beginning of the school year if their children have any health conditions that the school should be aware of. Nurses are engaged to help identified students prevent asthma exacerbation through prevention plans, and to plan for what to do in the event of an asthma attack. Most nurses collect data to describe their management of individual students with asthma in elementary, middle and high schools.

It is likely that school nurses are unaware of a significant proportion of students with asthma (about 37% of students with asthma, see Figure 71), potentially due to failure of parents to notify the school about the students' health condition. This estimate is based on a comparison of the number of students who have been identified by their parents as having asthma divided by the estimated number of students with asthma generated using student-reported prevalence from the Healthy Youth Survey.

The estimated asthma prevalence among K-12 students using parent-reported data was about 5% in comparison to 8-9% student asthma prevalence as reported by youth in the 2004 Healthy Youth Survey for grades 6-8-10-12 combined.

Figure 71: Percent students with asthma identified to school nurses, Washington State



Source: Office of the Superintendent of Public Instruction - School Nurse Corps, 2003-04 School Year and 2004 Healthy Youth Survey

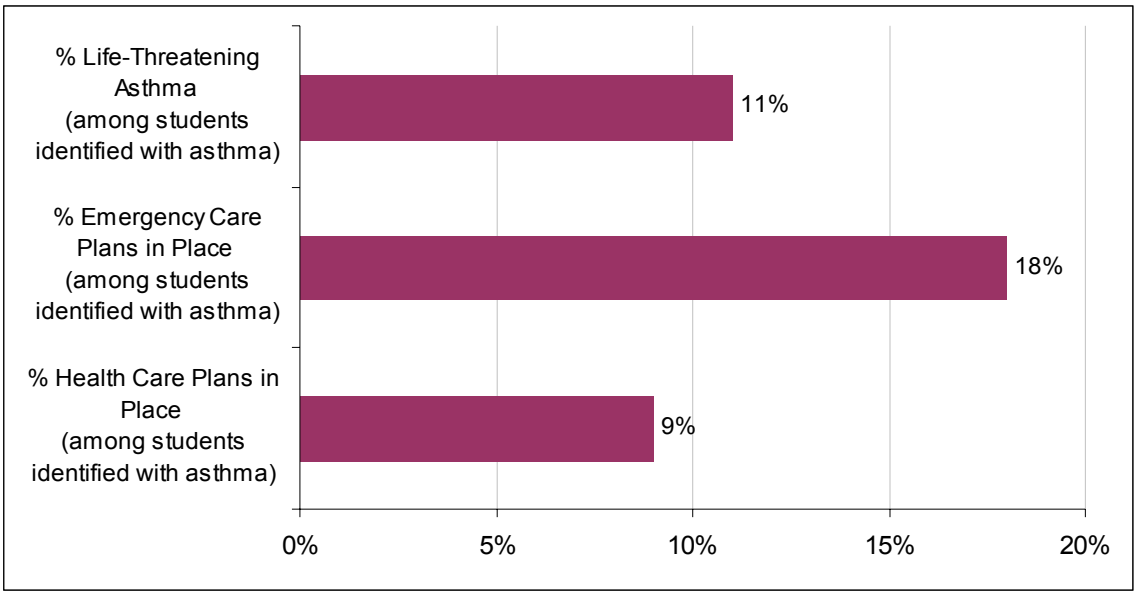
About 11% of the students identified with asthma are classified by school nurses as having "life-threatening asthma" (see Figure 72). This identification is required by state law, but a clear case definition has not been included in law. Instead, "life-threatening condition" is defined as "a health condition that will put the child in danger of death during the school day if a medication or treatment order and a nursing plan are not in

place."[112] Although asthma mortality among school-aged children is very rare, having asthma was associated with a lower quality of life (including depression and suicidal ideation), and uncontrolled asthma was associated with decreased academic achievement among youth [see Chapter 2]. Thus, providing support to all young people with asthma is important regardless of whether their condition is classified as "life-threatening" or not.

School nurses partner with families and healthcare providers to create Healthcare Plans (HCP) that describe any special precautions or accommodations that should be made for a student in normal school routine. For example, plans may describe precautions youth should take during physical education classes or in a chemistry laboratory where chemicals may be present. School nurses also create Emergency Care Plans (ECP) to describe what steps to take and whom to call in the even of an acute asthma event or attack.

Data reported by the School Nurse Corps suggest that ECPs were in place for most students with life-threatening asthma, assuming that students with life-threatening asthma receive priority for these plans (see Figure 72). About half as many youth with asthma had HCPs in place. Lack of resources to provide continuous nursing support, along with challenges to communication among parents, school nurses and healthcare providers are reasons why more prevention plans are not in place for students with asthma, including those not classified as having "life threatening" asthma.

Figure 72: Prevalence of asthma management indicators, among Washington students with asthma who are identified by school nurses



Source: Office of the Superintendent of Public Instruction - School Nurse Corps, 2003-04 School Year

School indoor air quality

Management of children with asthma in school settings must also consider issues of air quality inside the school. These school issues are discussed later in this report, in Chapter VII.

F. Self-Management

Finally, for effective asthma control, patients and their families must be educated and engaged to change their personal environments to remove any agents that trigger asthma attacks (see chapter VII). This information can also be included in the asthma care plan created in partnership with the healthcare provider for the school. The next chapter provides more detail about the types of exposures that are known to trigger or cause asthma attacks.

The core of self-management is the individualized asthma care plan. As noted earlier, Washington state data for adults on written asthma plans are not available. Data for youth on written asthma plans are difficult to interpret. The school principals report that 76% of schools obtain and use an asthma action plan for all students with asthma. But, only about one-third of youth with asthma report that they had received a written asthma plan from their healthcare provider. The school nurses report that only about 9% of the students identified with asthma have a Healthcare Plan. There may be explanations for these discrepancies (such as some overly optimistic reporting by principals, or some overly pessimistic reporting by nurses, or both), but it seems likely that many if not most youth lack coordinated care based on a written care plan that has been shared between their clinical healthcare provider and their school-based healthcare provider. This represents a missed opportunity to promote better self-management for effective asthma control.

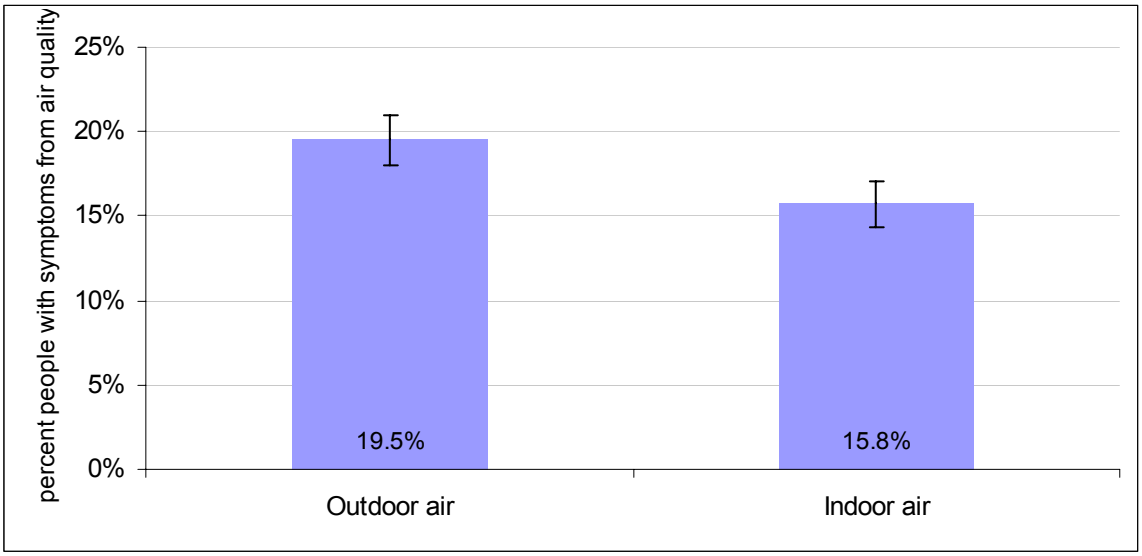
VII. Environmental Risk Factors for Asthma

Environmental and occupational exposures contribute to illness and disability from asthma. Some individuals are more vulnerable to asthma due to individual risk factors (previously discussed in chapters IV and V), and some exposures have only been proven to cause or trigger asthma within certain vulnerable population groups (such as children) or under certain conditions (dose levels).

Environmental asthma controls are an essential complement to clinical asthma controls. For example, a child with asthma can obtain the best quality of medical care possible, but if she sleeps every night in a bed filled with dust mites, and has pets that sleep in the bed beside her, then her symptoms may remain if either of those is a trigger for her.

In 1996, Washington adults were asked as part of a statewide survey whether they had experienced symptoms or discomfort such as headaches, coughing or difficulty breathing as a result of indoor or outdoor air quality. At that time, significantly more adults reported symptoms from outdoor air exposure than from indoor air exposure (19.5% vs. 15.8%, see Figure 73).

Figure 73: Prevalence of symptoms/discomfort as a result of air quality, among Washington adults



Source: Washington State BRFSS 1996

In fact, there are a number of exposures in both outdoor and indoor air that can affect the health of Washington residents, specifically some exposures are known to cause asthma or trigger asthma attacks.

Proven Exposures

New research is constantly published to describe associations between exposure to specific agents or groups of agents related to health outcomes. Sometimes different studies have conflicting results. For the purpose of identifying and discussing specific exposures that affect asthma within this report only major review reports and a few key studies (including from Washington State) were considered. Only agents cited in reviews that were identified as having at least "sufficient cause of association" for asthma are included in this discussion; these are agents where multiple studies have observed relationships between the exposure and the outcome (causing or exacerbating asthma) where chance, bias, and confounding can be ruled out with reasonable confidence.

The threshold of "proof" chosen for this report is conservative and likely excludes real environmental causes and triggers of asthma identified in more recent articles and reviews; however, the purpose of selecting exposures for description is to frame the discussion about what specific information is available to describe exposures in Washington, not to provide an exhaustive review of the literature or recommend which agents should be prioritized for action.

Outdoor Exposures

Agents that are known to cause or aggravate asthma include the following.[113,114]

Table 2: Outdoor air exposures that cause or trigger asthma

Pollutant	Source	Effect on Asthma
Ozone	Principal component of urban smog, usually greatest on hot summer days. Formed when vehicle and industrial emissions react with sunlight.	Exposure associated with asthma development among children frequently playing outdoor sports.[121] Exposure increased symptoms and emergency room visits among people with asthma.[115]
Fine particulate matter (PM)	Easily inhaled tiny particles including dirt, soot, dust, smoke or unburned fuel, and aerosols suspended in the air that come from mobile vehicles – especially diesel exhaust, construction, mining, wood smoke, fireplace or backyard burning, agricultural burning, wildfires and industry.	Exposure increased symptoms and emergency room visits among people with asthma, decreased lung function.[116,117.118,120]
Carbon Monoxide	Combustion, including motor vehicles and woodsmoke	Exposure increased symptoms among people with asthma.[116,117]
Nitrogen oxides (NO_X)	Fuel emissions from mobile sources such as cars or trucks and also power plants.	Exposure increased symptoms among people with asthma.
Sulfur dioxide (SO_2)	Typically from industrial sources, such as power plants, that burn sulfur-containing fuels like coal and oil. Mt. St. Helens is also a periodically significant source of SO_2 in Washington State.	Exposure increased symptoms among people with asthma.

Polluted outdoor air, such as from particulate matter (PM) and ozone, can cause or worsen lung-related diseases, such as emphysema, chronic bronchitis and asthma.[119] Diesel exhaust from mobile vehicles is of particular concern as an air toxic, as it has been identified as a probable cause of cancer, an allergen and also an asthma trigger.

Air pollution exposure reduces lung function and lung growth in children.[120] Children with asthma have been observed to have more lower respiratory tract symptoms on days with poor air quality,[121] and a study conducted in Seattle found that days with increased air pollution (measured as particulate matter and carbon monoxide from combustion sources such as cars, trucks, boats, or woodstoves) increased children's symptoms for asthma even though average concentrations were better than the National Ambient Air Quality Standard.[122] A longitudinal study of children in California found that children's

lung function decreased with regard to outdoor air pollution (PM^{10} and Nitrogen oxides).[123] A follow-up of children in the California study who had moved from the original community found that children who moved to communities with less polluted air than their original community had increased growth in lung function while children who had moved to more polluted communities had decreased growth in lung function.[124] The same study found children in areas with high ozone and who frequently played outdoor sports developed asthma more often than children who lived in areas with lower ozone and those who lived there but did not frequently play outdoor sports.[125,126]

People, particularly children, with asthma have been observed to have increased emergency department visits for asthma as a direct result of poor air quality.[127] A Seattle study also found that on days with higher air pollution children's emergency department visits for asthma were increased.[128]

The Environmental Protection Agency (EPA) "Air Quality Index" (AQI) is a single air quality measure created by combining data from ambient air monitoring for a number of pollutants. EPA calculates the AQI for five major air pollutants regulated by the Clean Air Act: ground-level ozone, particle pollution (also known as particulate matter), carbon monoxide, sulfur dioxide, and nitrogen dioxide.[129] It is important for sensitive populations (including people with asthma) and organizations responsible for protecting groups of people who may be affected (including schools and daycare centers) to check the EPA Air Quality Index on a daily basis to determine whether outdoor air quality is likely to affect their asthma.

National Objectives

Healthy People 2010 includes a number of environmental health objectives for improving air quality to benefit general health. These objectives were not specifically identified for asthma, but to improve respiratory health more generally, and text of the objectives has been modified to be specific to the asthma-related content. Washington data were not currently available to measure achievement of these goals.

Healthy People 2010 Objective 8-1
Reduce the proportion of persons exposed to air that does not meet the Environmental Protection Agency's health-based standards for harmful air pollutants

Target: Zero percent of the population exposed to

- Ozone – by year 2012
- Particulate Matter (PM) – by year 2018
- Carbon Monoxide
- Nitrogen Dioxide
- Sulfur Dioxide

Healthy People 2010 Objective 8-2
Increase use of alternative modes of transportation to reduce motor vehicle emissions and improve the Nation's air quality.

Target:
- Trips made by bicycling – 1.8%
- Trips made by walking – 10.8%
- Trips made by transit – 3.6%
- Persons who telecommute - developmental

Healthy People 2010 Objective 8-3
Improve the Nation's air quality by increasing the use of cleaner alternative fuels.

Target: 30% of US fuel consumption

Healthy People 2010 Objective 8-4
Reduce air toxic emissions to decrease the risk of adverse health effects caused by airborne toxics.

Target: 20 million tons (released annually in US)

Indoor Exposures

Indoor air exposures may be more easily modified than outdoor exposures. People can make changes to immediately improve indoor air in worksites, schools and homes. Indoor air quality, however, is influenced by outdoor air quality because outdoor air is drawn indoors continually.

Table 3 summarizes reviews of the evidence for indoor air exposures that can influence asthma that have been published by the Institute of Medicine and others. [104,130,113] If an agent or chemical was found to have "sufficient cause" as an asthma trigger, then information is also presented about findings of association as a cause of asthma even if the evidence is limited (e.g. indoor chemical exposures or dampness).

Table 3: Indoor air exposures proven to cause or trigger asthma

Indoor Air Exposure	Cause of Asthma	Trigger of Asthma (Exacerbation)
Dust Mite Allergen	XXX	XXX
Cockroach Allergen	XX*	XXX
Dog Allergen		XX
Cat Allergen		XXX
Fungi/Mold		XX
Secondhand Tobacco Smoke	XX*	XXX
Indoor Chemical Exposures (Fragrances, non-specific exposures)	X	XX
Dampness Indoors/Home	X	XX
NO_2 (e.g. gas appliances in poorly ventilated kitchens)		XX

Table Key: * among young children only
X = Limited evidence for association; XX = Sufficient evidence for association; XXX = Sufficient evidence for causation
Source: Institute of Medicine reports,[104,130] updated using Etzel.[113]

Some of the exposures indicated could be easily reduced or modified in environments. Pets can be removed from the household or at least restricted from certain parts of the house, smoking can be banned indoors and near entryways or air intake systems, and fragrance-free products (including cleaning agents) can be used.

Reduction of dust mites and cockroaches may be more difficult. Dust mites are tiny creatures of microscopic size (similar to spiders or ticks) that live in bedding or other soft materials and feed on the dead skin that falls from people and animals, thus good cleaning and removal of habitat (e.g., dust covers on mattresses, removal of carpeting, stuffed animals from children's rooms).

Routine cleaning practices can help control cockroaches, but these pests can survive even in clean homes. Approaches to control may include making sure homes are structurally sealed to prevent re-entry and not leaving food or water out.

Indoor air dampness and mold control requiring both cleaning and structural solutions, which can be intensive. Homes should be sealed and checked to assure that water is not seeping in, plumbing is not leaking, and ventilation should be checked to assure that dampness indoors is vented out (bathrooms, kitchens). Maintaining good ventilation is also important for controlling emissions from gas appliances, and includes simply checking that existing fans are working properly and turned on as needed. Wood-burning stoves should be EPA certified and stoves/fire places should be maintained and chimneys inspected to make sure they are functioning properly; whenever possible alternative sources of heat such as gas or electric should be used

Secondhand smoke is a notable exposure that is present in both home and some worksite settings. Exposure to secondhand smoke exacerbates asthma in a number of ways. In a variety of studies, exposed children with asthma had a more frequent need for emergency services,[82] a greater need for medications,[87] and a more difficult time recovering from an acute asthmatic episode.[131 132] Much of the literature has focused on secondhand smoke exposure and childhood asthma, however a number of studies have linked secondhand smoke exposure with adult-onset asthma.[78 133 134 135 136 137] A recent study by Jaakola and colleagues[138] was the first to report that both cumulative lifetime and recent exposures increase the risk of asthma, in both the home and workplace. In this study, exposure in the past year at workplaces increased the risk over twofold, and at home almost fivefold. The authors also calculated that almost 50% of new adult asthma cases occurring among adults exposed to secondhand smoke during the past year were attributable to that exposure.

According to the criteria established by the Association of Occupational and Environmental Health Clinics for designating substances as work-related asthmagens, there are currently over 350 substances known to cause asthma in the workplace. These include chemicals, dusts, metals, plant and animal materials, and proteins, among others.[139]

National Objectives for Indoor Air

The national objectives listed below were included in the Environmental Health chapter for Healthy People 2010 to promote "Healthy Homes and Healthy Communities". Washington data were not available at this time to measure relative status for these objectives.

Healthy People 2010 Objective 8-16
Reduce indoor allergen levels.

Target: expressed as "percent of homes"

- Group I dust mite allergens that exceed 2 micrograms per gram of dust in the bed – 29.0%
- Group I dust mite allergens that exceed 10 micrograms per gram of dust in the bed – 14.9%
- German cockroach allergens that exceed 0.1 microgram per gram of dust in the bed – 3.8%

Healthy People 2010 Objective 8-17
Increase the number of office buildings that are managed using good indoor air quality practices.

Target: Developmental

Healthy People 2010 Objective 8-20
Increase the proportion of the Nation's primary and secondary schools that have official school policies ensuring the safety of students and staff from environmental hazards, such as chemicals in special classrooms and poor indoor air quality.

Target: Developmental

(original objective text includes asbestos and pesticides, not specifically linked to asthma)

Healthy People 2010 Objective 8-23
Reduce the proportion of occupied housing units that are substandard.

Target: 3%

A. Communities

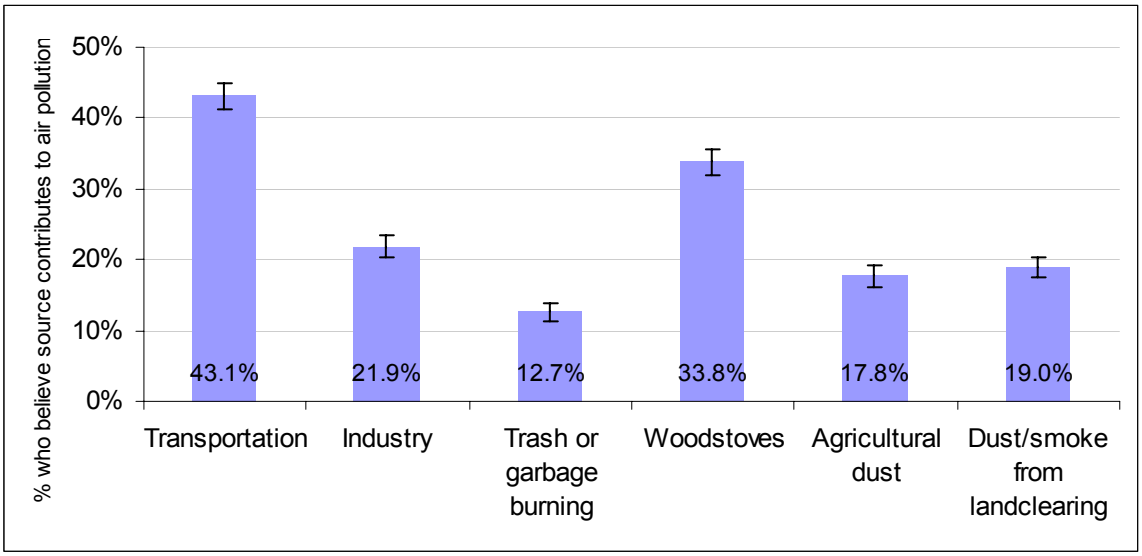
This section describes what is known about air quality in our communities – the state, counties, cities and other geographic areas where people live.

Outdoor/Ambient Air

Washington adults report believing that outdoor air contributes to asthma. A national poll conducted in 2000 that included more than 800 registered voters from Washington State found that 57% believe that environmental factors play a major role in causing asthma among children and an additional 27% believe that environmental factors play a minor role in causing asthma among children.[140] In the study, Washington adults ranked asthma as second among health conditions that they perceived the environment has a major role in causing (behind allergy and sinus problems).

As part of the Washington BRFSS adults were asked about what sources they believe contribute to outdoor air pollution. Transportation and woodstoves were identified as most commonly believed to be outdoor air pollution contributors, followed by industry, dust/smoke and agricultural dust, and trash or garbage burning were perceived as having the least impact (see Figure 74).

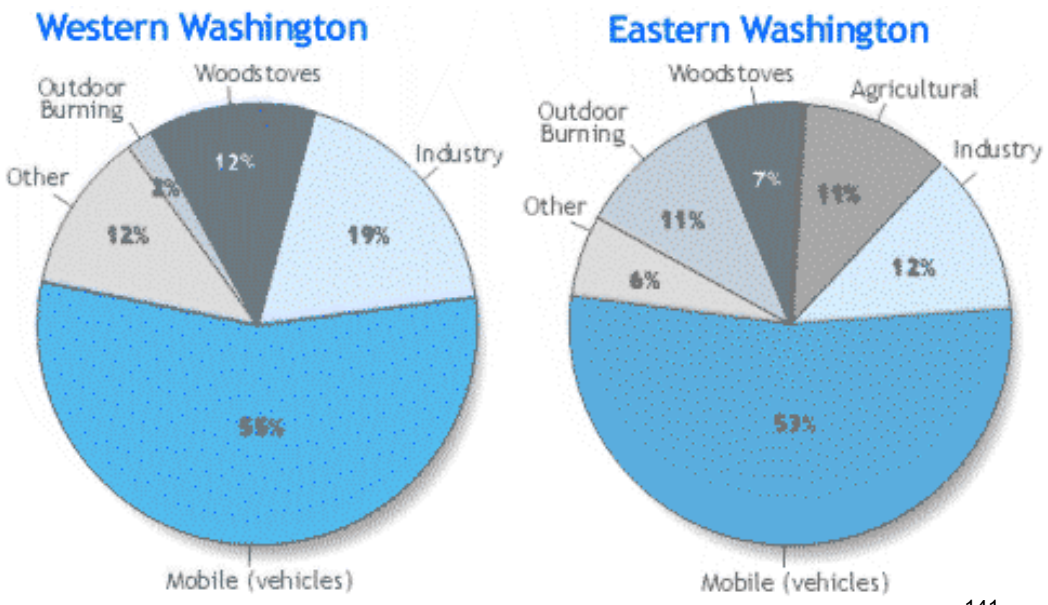
Figure 74: Prevalence of belief about contributors to outdoor air pollution, among Washington adults



Source: Washington State Behavioral Risk Factor Surveillance System (BRFSS) 1996

Findings from these attitudinal reports are not inconsistent with actual factors identified by the Department of Ecology as contributing to poor air quality as particulate matter (see Figure 75). The primary cause of poor air quality in Washington is mobile vehicle exhaust. There are some differences in actual sources of pollutants between Eastern and Western Washington. In Eastern Washington agricultural practices and outdoor burning are leading contributors to poor air quality, while in Western Washington woodstoves and industry are comparatively more important.

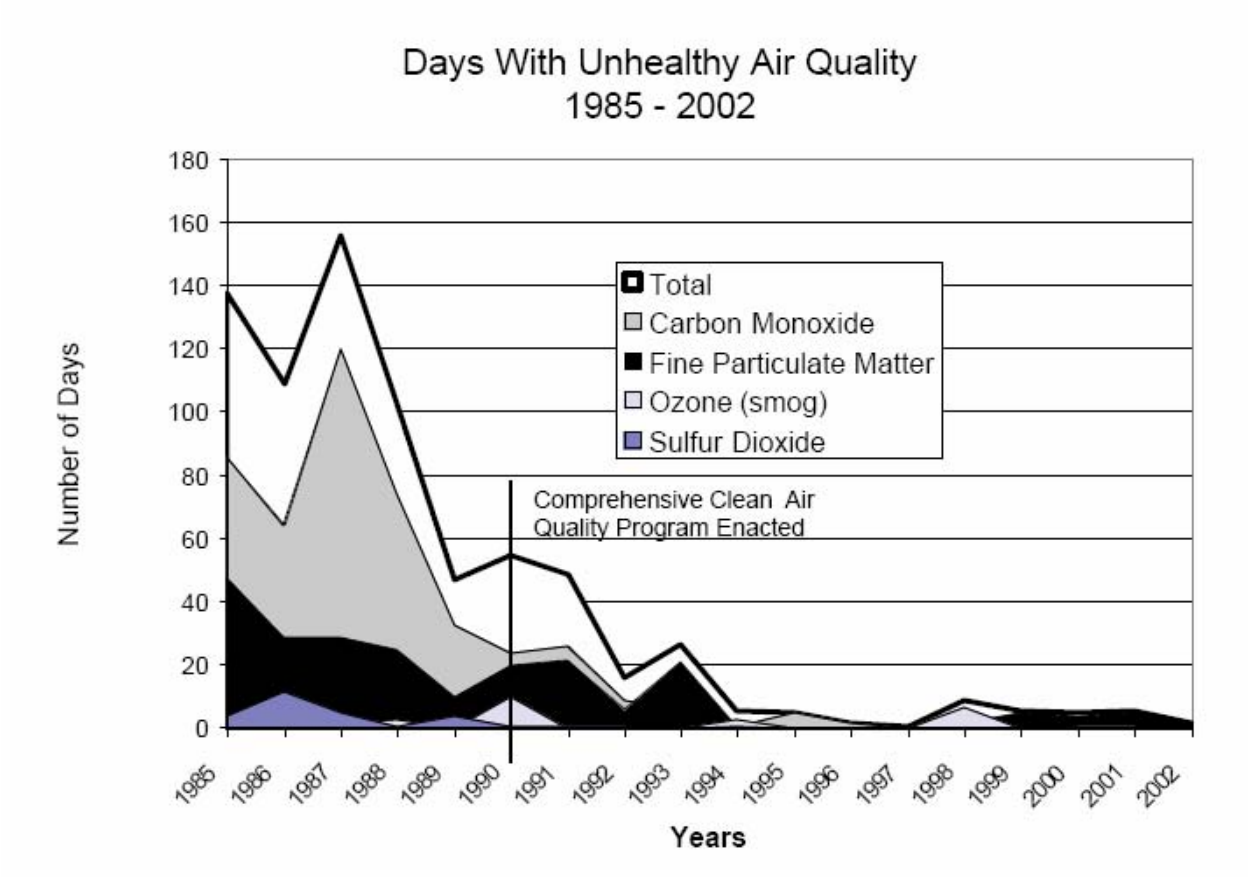
Figure 75: Factors that contribute to poor air quality in Washington State



Source: Washington State Department of Ecology, Environmental Health in Washington State 2000[141]

Washington's outdoor air quality is generally considered moderate to good.[141] The air quality has improved over the last ten years as measured by the number of days that air quality in Washington did not meet health standards for carbon monoxide, particulate matter, ground-level ozone and sulfur dioxide for the state overall (see Figure 76). Substantial improvement has been made overall since implementation of clean air policies in the early 1990s; however, fine particulate matter were not decreased in 2000-2002. Our growing population and the miles we travel by car continue to threaten the quality of our air.

Figure 76: Trends for "unhealthy air quality days" in Washington State

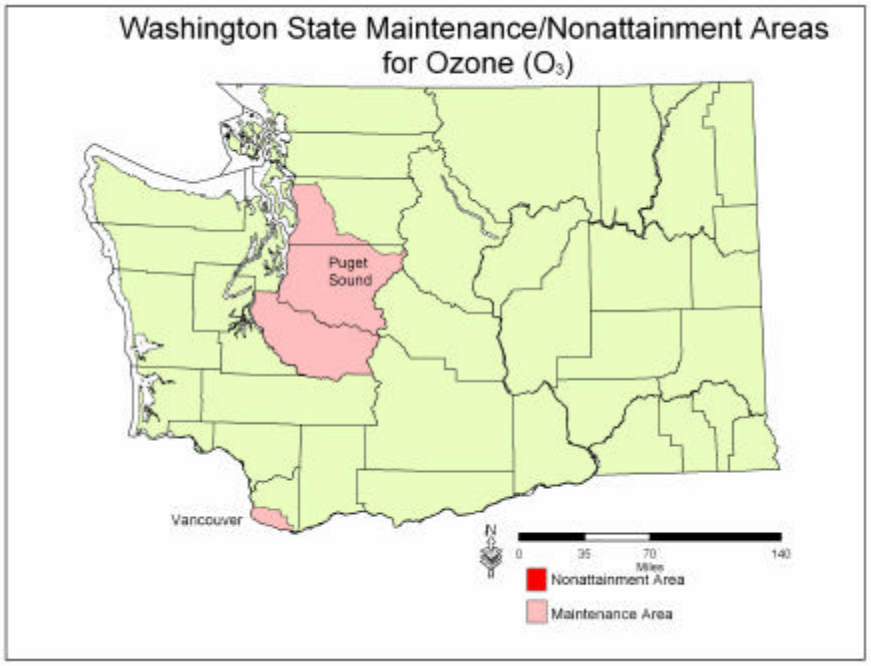


Source: Washington State Department of Ecology, April 2003[142]

Specific programs, such as those to encourage retrofit of diesel vehicles, including school buses, to reduce particulate matter,[143] will contribute to continued improvement in outdoor air quality.†††† Despite progress in achieving clean outdoor air statewide, specific geographic areas remain at increased risk for poor air quality. For example, the Puget Sound region and Vancouver remain areas of concern for ozone (see Figure 77). Spokane, Yakima, and Wallula are all out of attainment for PM, and the Kent Valley, Seattle Duwamish, Tacoma Tideflats, and Thurston County are all in maintenance (see Figure 78). For people with severe asthma in these communities in particular, it may be important to monitor air quality on a daily basis and modify outdoor activities accordingly.

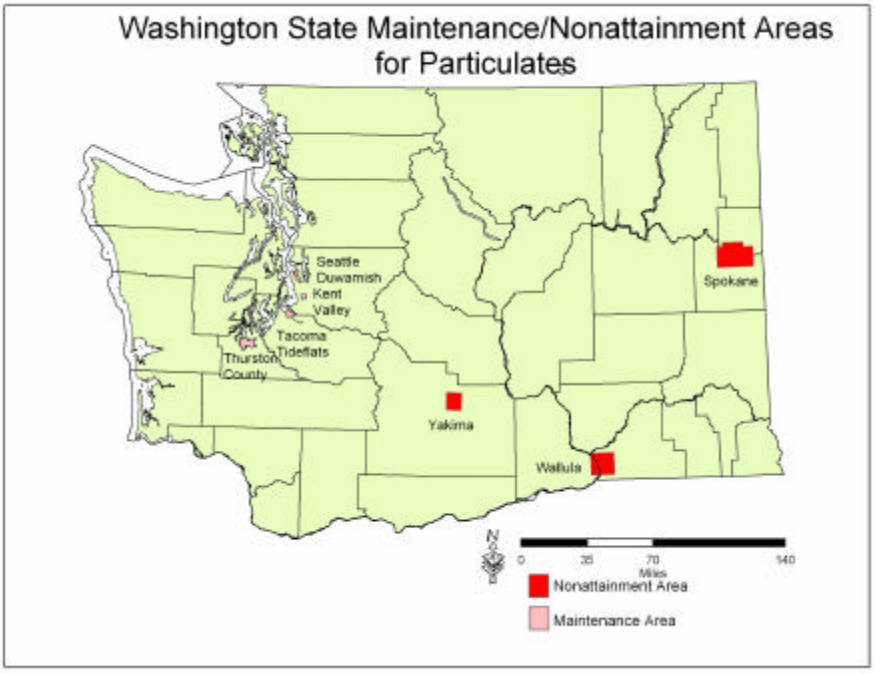
†††† EPA regulations require that by 2007 new diesel engines must meet lower vehicle emission standards, however this will not affect vehicles that are already on the road

Figure 77: Maintenance/nonattainment areas for ozone in Washington State



Source: Washington State Department of Ecology[142]

Figure 78: Maintenance/nonattainment areas for particulate matter (PM) in Washington State



Source: Washington State Department of Ecology [142]

Indoor Air

The primary concern for communities is ambient, or outdoor air. This means the general air in a geographic area. Community leaders can play a role in improving indoor air environments by providing education or creating and enforcing rules that assure clean indoor air quality in buildings that serve the public. Specifically, communities can work to improve indoor air quality in worksites (general exposures, such as secondhand smoke, rather than specific occupational exposures), government buildings and libraries, daycare facilities, churches or worship settings, and group home facilities. Discussion in the following sections on worksites and homes are relevant to these potential efforts.

B. Schools

Indoor Air

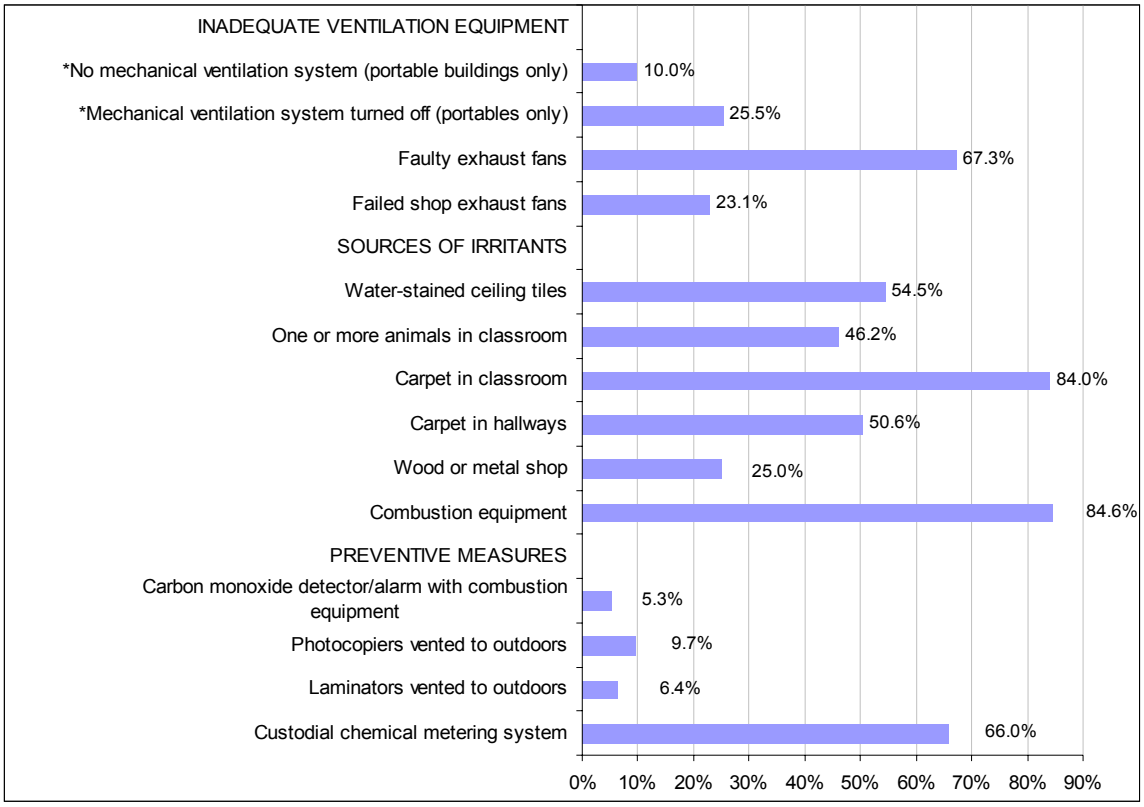
Facilities and practices within school buildings can have a substantial effect on air quality. A survey of several thousand classrooms in Washington and Idaho public schools (3,801 total classrooms, with about 5% of these rooms in "portable" or "relocatable" buildings) found that a substantial proportion of school buildings had risk factors for poor air quality, and only a few had protective measures in place (see Figure 79).[144]

About one in four "portable" buildings had turned off their ventilation systems (presumably because of noise). Two-thirds of school buildings had faulty exhaust fans. Other common sources of asthma-related pollutants in these school buildings included evidence of dampness (water stains on ceiling tiles in 54% of buildings), sources of animal dander allergens, carpeting which can harbor dust mites, pollens or mold, and sources of chemical irritants. Most prevalent were classroom carpets and combustion equipment.

Very few school buildings had protective measures in place to assure that sources of pollution were minimized. Fewer than 10% had ventilation of copiers or laminators to the outdoors. Less than one in twenty schools had a carbon monoxide alarm located around combustion equipment.[‡‡‡‡]

[‡‡‡‡] Carbon monoxide in this case is not a trigger for asthma, but a marker for poor function of ventilation equipment (leaking of fuel or incomplete burning of fuel)

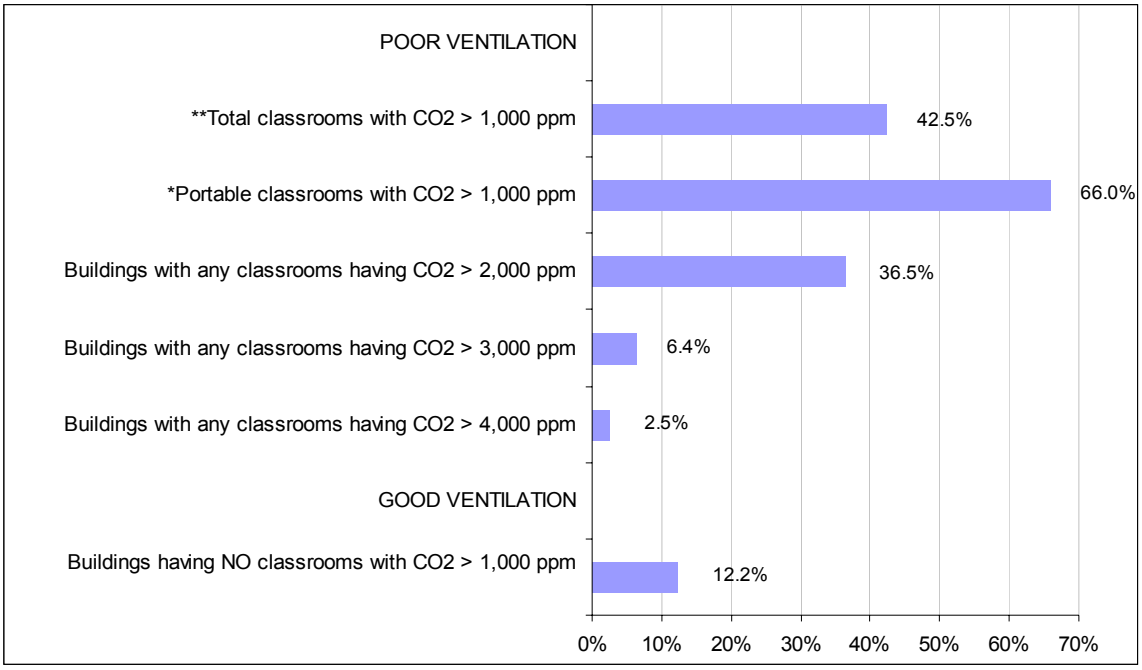
Figure 79: Prevalence of risk factors for poor indoor air quality, among Northwest schools



Source: Washington and Idaho schools included in Prill et al.[144] [Note: Measures marked * are of portable classrooms; remaining percentages are for school buildings, not classrooms.]

The same study in Washington and Idaho public schools found that that nearly half of the classrooms monitored had short-term measures of poor air quality, using carbon dioxide concentration – CO_2 parts per million -- as a proxy for air quality (see Figure 80). Further research in a subset of these schools found that reduced outside air ventilation, indicated by elevated carbon dioxide concentrations, was associated with 10-20% increases in student absence.[145] The reduced attendance was observed among the general student population, thus maintaining good indoor air quality is important in supporting the educational success of all students, not only important for students with asthma.

Figure 80: Prevalence of poor indoor air quality, among Northwest schools



Source: Washington and Idaho schools included in Prill et al.[144][Note: Measures marked * for portable classrooms and ** for total classrooms; remaining percentages are for buildings.]

Ambient Air Surrounding Schools

As discussed previously, mobile vehicles – including school buses and vehicles driven by students, parents and staff – are among the major contributors to air pollution. Data to specifically measure outdoor air quality surrounding schools are not available, however a five-year program was authorized by the 2003 State Legislature[§§§§] to retrofit diesel bus engines in 7,500 diesel school buses (about three-quarters of the existing fleet) by 2008. Some Washington schools have additionally instituted "No Idle Zone" campaigns to reduce emissions from both buses and parents waiting for students. The average idling time of motor vehicles was reduced around schools that participated in pilot anti-idling campaign.[146] Data are not yet available to describe the air quality or health outcome improvements expected as a result of these programs.

C. Worksites

Occupational Exposures

Recent studies in the U.S. have found that in working adults, between 10 and 26 percent of new onset asthma is attributable to work-related asthma.[147] [148] Occupational factors cause or trigger asthma episodes in 5 to 30 percent of adults with the disease. [149]

Depending on the type and intensity of work exposures, the frequency of work-related asthma may be very high in some industrial settings (e.g., about 25 percent in one group of platinum-refinery workers); in other industries, only sporadic cases may be reported.[150]

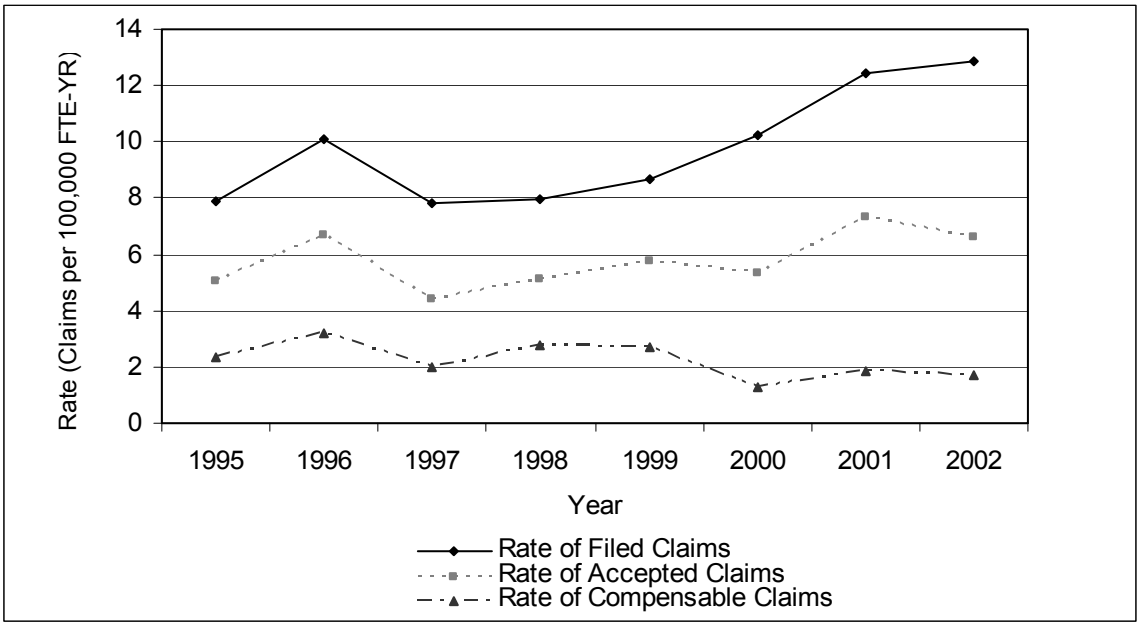
[§§§§] ESSB 6072

In Washington, a study from the Washington State Department of Labor and Industries (L&I)[15] documented a total of 1,377 claims for compensation for work-related asthma received by L&I from 1995 to 2002. Approximately 59% of the claims were accepted as valid. Over half the claims were filed by women, and claimants ranged in age from 15 to 77 years, with an average age of 41 years.

To be accepted (and compensated), claims must meet the following criteria: (1) a physician must give opinion that it is a probable (greater than 50%) that work conditions are the cause of illness or have aggravated a pre-existing condition; (2) objective medical findings must support the diagnosis; and (3) the disease must arise directly out of employment. Information about the cost of claims was presented in Chapter II of this report.

The rate of total claims increased significantly from 7.9 to 12.9 per 100,000 full-time employee (FTE) during this time period (see Figure 81). The rate of accepted claims also increased from 5.0 to 6.6 per 100,000 FTE. This suggest that incidents of work-related asthma are increasing, which may reflect (or contribute to) the increase in the population prevalence of asthma among adults. These estimates are likely an underestimate, because work-related asthma is generally thought to be under recognized and underreported to the workers' compensation system. Further, not all workers are covered by the workers' compensation state fund, such as federal employees and the self-employed.

Figure 81: Trends in work compensation claims for asthma, Washington State



Source: Labor & Industries Worker Compensation Claims Data. Curwick, et al.[15]

Diverse work environment and worker exposures were represented among the claims reported. Worksites included in claims were sawmills, plastics, wood, and fiberglass products manufacturing, office environments for clerical workers, and medical clinics. Exposures included paint or painting compounds; flame or smoke; infection or parasitic

agents (including mold); wood dusts; and other unidentified or unclassified particles or chemicals. Workers affected were laborers, trade workers, farm workers, managers and administrators, and retail or personal sales workers.

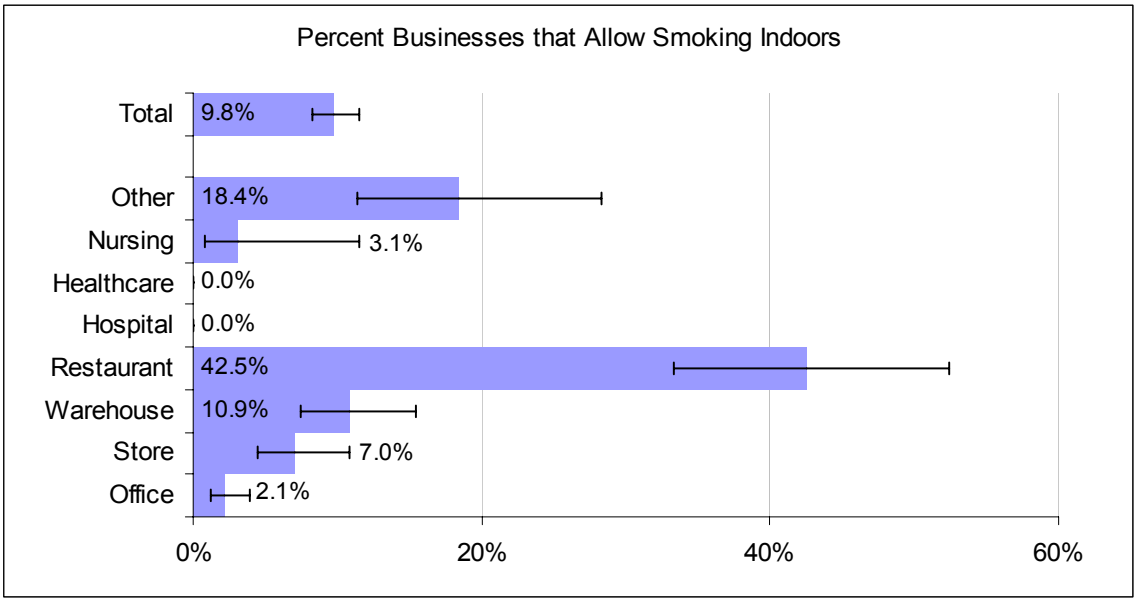
These trends suggest an increasing incidence of work-related asthma claims in Washington. The authors of the Labor and Industries report mention the contrast between this trend and the declining claim incidence rates for other types of occupational illnesses and injuries. Clearly, prevention efforts for work-related asthma are a priority, and multiple industries and exposures must be targeted.[15]

Workplace Indoor Air

As indicated previously, there are diverse possibilities for occupational exposures that put workers at risk for asthma. Exposure types are related to specific job conditions and equipment or materials. The wide variety of worksites and exposures makes development of effective safety measures and education of worksite managers challenging.

One exposure present in a variety of worksites is secondhand smoke. State law bans smoking in most workplaces (Chapter 70.94 RCW, Washington State Clean Indoor Air Act) but restaurants, bars, casinos, and some other worksites are currently exempted from that ban. A recent survey of large worksites in Washington found that about 43% of restaurants allow smoking, as well as 11% of warehouses, one in five mixed businesses (including agricultural and industrial facilities), and a small proportion of nursing homes (see Figure 82). A few casinos and bar/pubs were also randomly selected as part of the survey, and although their small number (N=20) prevents generalization to casinos and bars statewide, all of those interviewed (100%) allowed smoking indoors. Worksites such as restaurants, bars, and casinos are of particular interest because the visiting public may be exposed to smoke the same as the workers.

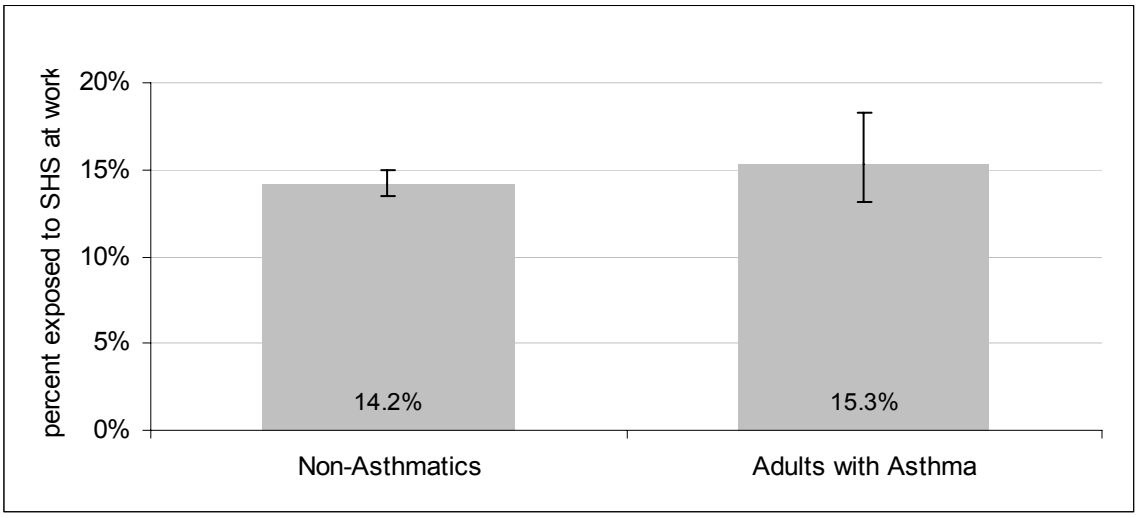
Figure 82: Prevalence of rules allowing indoor smoking by worksite type, among large Washington worksites



Source: 2004 Washington State Worksite Policy Survey, employers with 50+ employees only.

People with asthma should avoid secondhand smoke exposure (as well as smoking) as part of a good asthma control plan. This suggests that people with asthma (non-smokers) should avoid working in environments where they are exposed to secondhand smoke on the job. There was no difference in self-reported occupational exposure to secondhand smoke between people with asthma and people who do not have asthma (see Figure 83). It is possible that people with asthma are more sensitized to exposure, and over-report their exposure in comparison to people without asthma. Alternatively, given that asthma is most prevalent among the least educated people, it is possible that people with asthma are not able to select among jobs for one where they are not exposed.

Figure 83: Prevalence of exposure to secondhand smoke (SHS) at work by asthma status, among Washington adult non-smokers



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS).

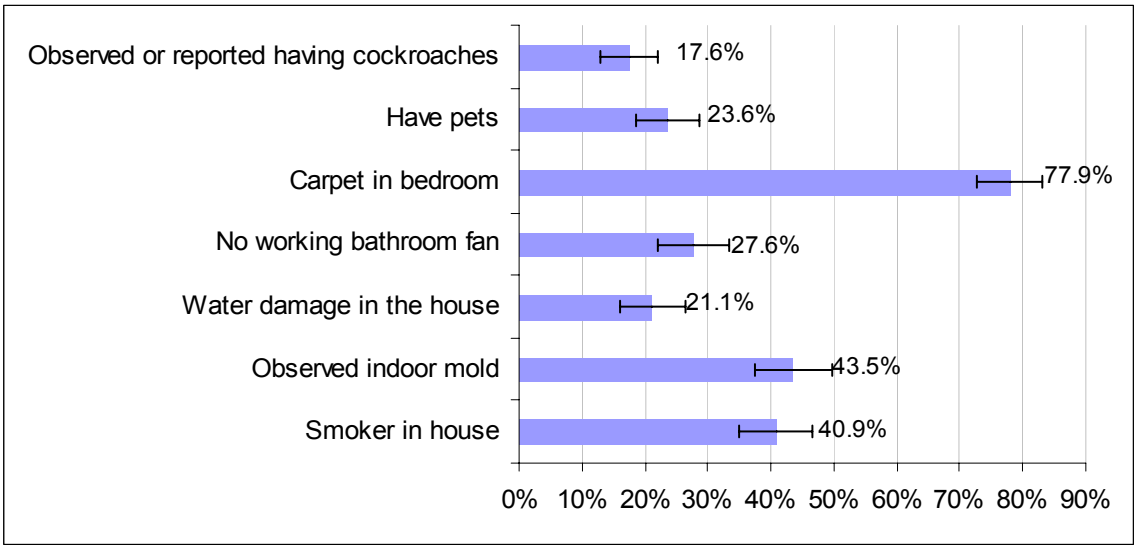
D. Homes

Individual homes are one place where people with asthma and their families can assure the safest environment possible. Homes can include a variety of structures, such as private houses, group houses, apartments, mobile homes, or institutional homes.

Given that asthma is associated with low income, it may be of particular importance for administrators of group or public housing facilities to assure that group homes or public housing environments are safe and free from asthma-related exposures. Home-based childcare businesses can serve large numbers of children over time, and given that children are particularly vulnerable to developing asthma or asthma exacerbation from home exposures it is important to assure that childcare providers are aware of what they can do to make their homes as safe as possible for those children.

Washington State does not have data to describe general household triggers among people with asthma statewide or to describe to what extent Healthy People objectives for clean home environments are being met; however, a study conducted among low-income residents in King County[151 152] provides some suggestion that the level of exposure to home triggers among people with asthma is high. This study was conducted among a low income group of people with asthma. Prior to an intervention to educate people with asthma about things they can do in the home to reduce common triggers, an assessment of the existence of those triggers was conducted. About one in five people with asthma in the study reported exposure to cockroaches and/or water damage; about one in four had pets and/or did not have a working bathroom fan; two out of five had indoor mold and/or were exposed to cigarette smoke indoors; and nearly eight out of ten had carpet in their bedrooms (see Figure 84).

Figure 84: Baseline prevalence of home triggers for asthma, among Seattle-King County asthma study participants



Source: Seattle-King County Healthy Homes Project[153]

These data are from a high-risk (low income) population groups. For low income people, structural or building-related risk factors, such as physical defects in an apartment, may be outside of their individual control. The repairs required to prevent cockroaches from entering a home, or water damage, or removal of carpet, may be too expensive or not possible for renters to complete. Changing those risk factors may require more community-level interventions to support structural improvements in existing or new high-risk housing.

Some of these factors, such as pets and home smoking, can be addressed through policies at group housing facilities (such as apartments or dormitories). Others factors may be better addressed by increasing knowledge among individuals about managing their home environment. For example, baseline data from a pilot project conducted in the Yakima region indicated that while about two-thirds of families that had a child with asthma did vacuum at least weekly (67%) and keep stuffed toys and furniture to a minimum (64%), only one-third (32%) banned pets from the child's room and very few (5%) had pillow and mattress covers to prevent exposure to dust mite allergen.[154]

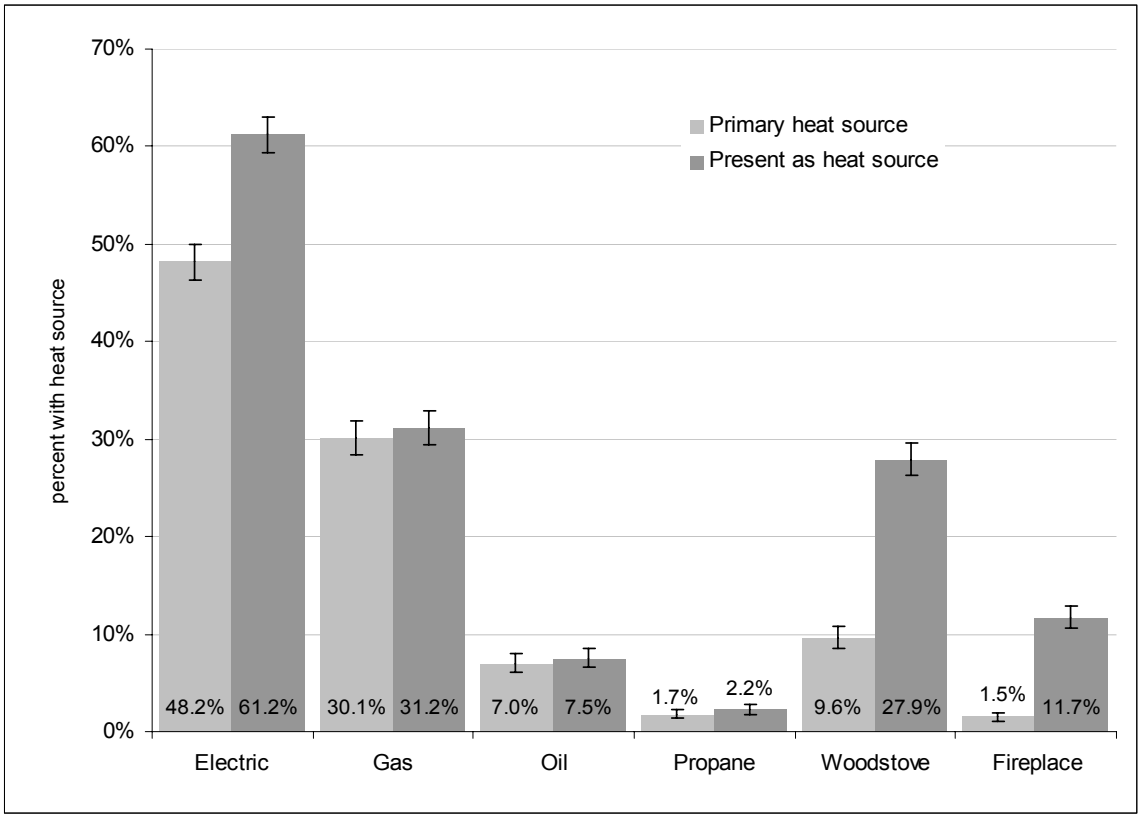
The findings suggest that people with asthma may need to be educated about things to do in their homes to reduce exposure to asthma triggers, such as appropriate cleaning for mold or reducing exposure to cockroaches in order to complement physical facility interventions.

Home Heating Sources

People can inadvertently create unhealthy homes by using heating sources that generate pollutants. For example, woodstoves and fireplaces can generate gases and particulate matter (PM) that exacerbate asthma.[143] Almost one in three Washington homes has a woodstove and more than one in ten has a fireplace (see Figure 85). These are not

frequently indicated as the primary heat source for the home, which could suggest that when they are operated they are less functional (such as uncertified woodstoves, not carefully maintained) and thus potentially even more hazardous to those living in the home.

Figure 85: Prevalence of heat sources in home (primary or available sources), among Washington adults



Source: 1996 BRFSS

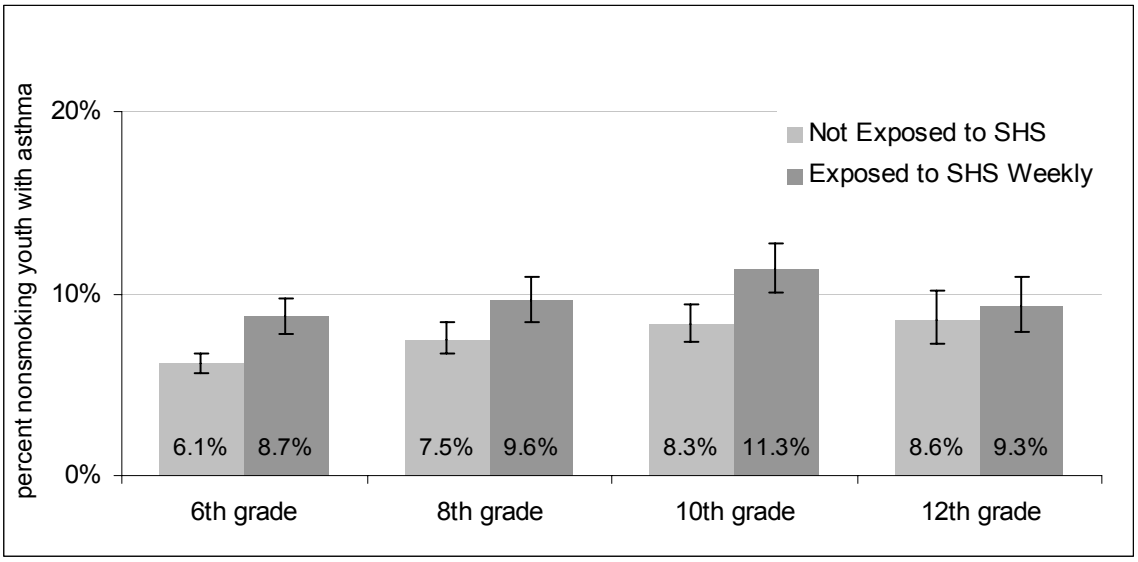
Secondhand Smoke

A common home exposure that is related to both asthma and low income status is secondhand smoke (SHS) – smoke from other people's cigarettes, pipes, or cigars. In Washington, exposure to SHS was significantly associated with greater asthma prevalence among non-smoking youth in 6th, 8th, and 10th grades in Washington (see Figure 86, $p<.001$ for 6th grade; $p=.007$ for 8th grade; $p<.001$ for 10th grade). For example, asthma prevalence among 6th graders who were not exposed to SHS was about 6%, while among youth who were exposed to SHS the asthma prevalence was about 9%. About one in ten youth with asthma overall reported being exposed to SHS during the past week.

Many studies have documented that parental smoking is associated with an increased risk of asthma development in children. In two large reviews of parental smoking and school-aged children,[155] [156] authors documented that parental smoking (by either parent) was associated with approximately 20% to 40% increased prevalence of asthma, which increased with the number of smokers in the home. Maternal smoking appeared to have a

greater association with asthma than paternal smoking, however paternal smoking alone was still a significant risk factor. Another review of ten papers[86] which looked at asthma onset, reported combined increased risks of 31% for children under age six, and 13% for those over six.

Figure 86: Prevalence of asthma by exposure to secondhand smoke (SHS) at home, among non-smoking Washington youth



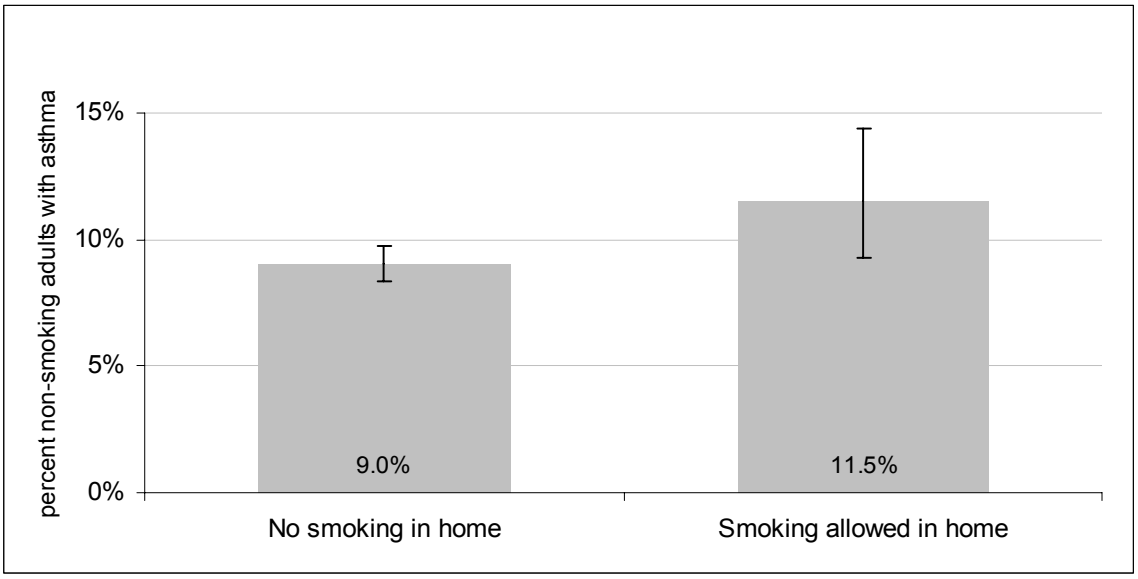
Source: 2002 and 2004 combined Washington State Healthy Youth Survey (HYS).

More than 40,000 children five and under in Washington State are estimated to be exposed to SHS in their homes. Of these children, approximately 500 new cases of asthma occurred each year as a result of the home exposure.[*****]

There was no association between exposure to SHS at home and asthma for non-smoking Washington adults (see Figure 87). About one in ten non-smoking adults (regardless of asthma status) reported being exposed to SHS at home.

[*****] see technical notes for calculation detail

Figure 87: Prevalence of asthma by exposure to secondhand smoke (SHS) at home, among non-smoking Washington adults



Source: 2003 Washington State Behavioral Risk Factor Surveillance System (BRFSS)

Although the differences were not significant for adults by asthma status, the data suggest a need to educate people with asthma and their families about the importance of not allowing smoking in the home.

VIII. Asthma and Health Disparities

Health disparities are unfair health burdens (in this case related to asthma) that result from "extra" exposure, prevalence or impact for a particular group of people. Potentially these may be biologically determined (physiologically vulnerable populations), but in particular we are interested in those differential impacts that arise from systematic creation or support of environmental risk factors or lack of access to effective asthma control for specific groups of people. That is, we are most interested in identifying disparities created as a result of how Washington State and its communities function, so that our society can "change the way it does business" to create health equity for all people.

As an example of an "environmental justice" investigation (disproportionate – or disparate – exposure of disenfranchised groups of people to environmental exposures), a 1995 study by the Washington State Department of Ecology found that there are a greater number of industrial facilities located in low-income and minority communities, which may be resulting in higher exposure among these residents.[157] Since a higher proportion of minority and low-income residents in Washington live in urban areas, these groups may also be exposed to higher than average levels of diesel exhaust.[158]

Many of the studies on racial/ethnic disparities in asthma, for example, have made an attempt to examine additional factors related to race/ethnicity that might account for differences in asthma rates. A study using the National Health and Nutrition Examination Study, found that low income was the strongest independent predictor of asthma, and that the black-white difference was largely explained by income disparity. [51] Another study, was able to examine urban residence, and found that after controlling for various factors, all urban children, regardless of race or income, were at increased risk for asthma. These and other studies [28 51 54 57 60 72 73 74] have pointed out the considerable possibility that increased exposures to air pollution (from inner-city residence), lack of access to healthcare, higher smoking prevalence, higher exposure to secondhand smoke both prenatally and postnatally, racial or ethnic differences in health beliefs regarding preventive medications, overcrowding, greater exposure to irritants such as cockroach allergens, are the factors that likely account for the observed racial disparities in asthma prevalence, morbidity and mortality.

The Washington State Board of Health recently completed a report describing the issue of environmental justice in Washington,[159] and this report called for promotion of "One Washington – a state where all residents experience the benefits of unprecedented prosperity, growth, clean air, clean water, and equal participation in government activities." This report identified low-income and minority communities as having a disparity for cancer and asthma related to their environmental exposures. The same report also identified significant disparities in availability of and access to health services exist between rural and urban Washington, between lower and higher income residents, and among racial and ethnic groups.

The identification of health disparities begins with examination of data. Unfortunately, public health surveillance systems (surveys), in order to operate as cost-efficiently as possible, may systematically fail with regard to particular populations. For example, as described earlier, the Washington BRFSS was only given in Spanish beginning in 2003 and so data collected prior to that time for Hispanic/Latino people would be biased toward more acculturated groups. Further, because it uses (non-cellular) telephone directory lists for sampling the BRFSS functionally excludes migrant farmworker populations (who are unlikely to obtain a telephone land line) and so even the addition of Spanish language will not assure that this important population in Washington is accurately described. Similarly, although the Healthy Youth Survey has been given in Spanish every year, it only captures information from youth enrolled in public school systems and therefore youth who have dropped out of school, or who attend non-public schools (including Tribal schools) are excluded. Also, although systems may appropriately capture all groups of people it may be difficult to identify some groups within that system. For example, Washington Death Certification data have been well documented to inaccurately capture Native American race, and therefore death rates for asthma or any other condition are likely to be under-reported for this group. Also, people who are gay, lesbian or bisexual have been included in surveys for years, but we could not identify who they were until a question about sexual orientation was added to BRFSS in 2003.

Public health surveys are continually evaluated for potential improvements so that they can include people as equitably as possible within the bounds of the resources they have to operate. Even when public health surveillance systems do operate as equitably as possible, small numbers of people from particular groups can be a barrier to their effective description. For example, as most residents in Washington are non-Hispanic and white, there are comparatively many fewer African American, Asian/Pacific Islander, Native American, or Hispanic/Latino included. Efforts to "oversample" these groups to improve their sample size, for example by geo-targeted sampling methods, can themselves introduce a new bias by effectively excluding minority group members who do not live in minority-dense areas.

Health disparities for asthma exist in Washington. Data presented in this report indicate that people with low incomes or less education, Native American, urban residents and lesbian/bisexual women may bear an unfair share of the burden of asthma. Some disparities may remain hidden; for example, prior to 2003 data suggested that Hispanics were at lower risk than non-Hispanics for asthma, but following addition of Spanish language to the survey we were able to find that more acculturated Hispanics have a similar asthma burden as non-Hispanics.

For the purpose of this report, all potential data that we could find to describe the burden of asthma in Washington have been identified and presented at least in summary. Future analyses will include more complex analyses intended to more completely identify and describe disparities for the purpose of informing public health advocates where their efforts can be best spent to create "One Washington" for asthma. None of the quantitative data sources, however, will ever completely describe populations to our satisfaction, and

thus more subjective information – case reports, community or institutional knowledge, and the beliefs of community leaders and members – must be actively included in any discussion about what groups are at greatest risk.

IX. Conclusions

This document describes the problem of asthma in Washington State. The evidence is strong that asthma harms all types of people and their families, and drains resources for systems that serve our population. The facts presented justify including asthma interventions as a public health priority, and also as a priority to be addressed within a variety of non-health systems.

The Washington State Asthma Plan, currently in development, will provide the action steps that our state will take to reduce the burden of asthma. In summary, this report argues that "people should care" and the Plan will provide the context for "what we can do about it."

Successful approaches in asthma prevention and control will include multidisciplinary partnerships among public health professionals and advocates, healthcare providers, school administrators and staff, business leaders, elected officials, community workers, and families. Working together we can make breathing easier for everyone in Washington State.

References

1 Centers for Disease Control and Prevention: National Center for Environmental Health Asthma Fact Sheet. http://www.cdc.gov/asthma/faqs.htm accessed 11-18-04.

2 Arif AA, Delclos GL, Whitehead LW, Tortolero SR, Lee ES. 2003. Occupational exposures associated with work-related asthma and work-related wheezing among US workers. Am J Ind Med. Oct;44(4):368-76.

3Youakim S. 2001. Work-related asthma. American Family Physician. Dec 1;64(11):1839-48.

4 Maier WC, Arrighi HM, Morray B, Llewllyn C, Redding GJ. The impact of asthma and asthma-like illness in Seattle school children. Journal of Clinical Epidemiology. 1998;51(7):557-68.

5 Guite HF, Dundas R, Burney PGJ. Risk factors for death from asthma, chronic obstructive pulmonary disease, and cardiovascular disease after a hospital admission for asthma. Thorax. 1999;54:301-307.

6 National Asthma Education Program. Guidelines for the Diagnosis and Management of Asthma. Bethesda, MD: US Department of Health and Human Services, National Institutes of Health Publication No. 91-3042;1991.

7 Strunk RC, Mrazek DA, Wolfson Fuhrmann GS, LaBrecque JF. Characteristics associated with deaths due to asthma in childhood: a case-controlled study. JAMA. 1985;254:1193-8.

8 Lieu TA, Quesenberry CP, Capra AM, et al. Outpatient management practices associated with reduced risk of pediatric asthma hospitalization and emergency department visits. Pediatrics 1997;100:334-341.

9 Morray B, Redding G. Factors associated with prolonged hospitalization of children with asthma. Arch Pediatr Adolesc Med 1995;149:276-279.

10 Russo MJ, McConnochie KM, McBride JT, et al. Increase in admission threshold explains stable asthma hospitalization rates. Pediatrics 1999;104:454-462

11 Global Initiative for Asthma (GINA). 2002. Global Strategy for Asthma Management and Prevention. National Institutes of Health. National Heart, Lung, and Blood Institute. NIH Pub: 02-3659. Available at www.ginasthma.com

12 Weiss KB, Sullivan SD. The health economics of asthma and rhinitis. I. Assessing the economic impact. J Allergy Clin Immunol 2001;107:3-8.

13 Smith DH, Malone DC, Lawson KA, Okamoto LJ, Battista C, Saunders WB. A national estimate of the economic costs of asthma. Am J Respir Crit Care Med. 1997.156;787-793.

14 Centers for Disease Control and Prevention. Smoking-Attributable Mortality, Morbidity, and Economic Costs (SAMMEC): Adult SAMMEC and Maternal and Child Health (MCH) SAMMEC software, 2004. Available at http://www.cdc.gov/tobacco/sammec. accessed 3-12-05

15 Curwick C, Bonauto D. Work-related Asthma in Washington State: A Review of Workers' Compensation Claims from 1995-2002. Washington State Department of Labor and Industries. Olympia, WA. 2003. Technical report number 64-6-2003.

16 Mannino DM, Homa DM, Akinbami LJ et al. Surveillance for Asthma – United States, 1980-1999. In: Surveillance Summaries, March 29, 2002. MMWR 2002;51(No. SS-1): 1-13.

17 CDC. Asthma surveillance -- United States, 1980-1999. MMWR CDC Surveill Summ 2002;51(SS-01):1-13. Available at <http://www.cdc.gov/mmwr/preview/mmwrhtml/ss5101a1.htm>.

18 Dey AN, Schiller JS, Tai DA. Summary Health Statistics for U.S. Children: National Health Interview Survey, 2002. National Center for Health Statisticsl Vital Health Stat 10(221). 2004.

19 GlaxoSmithKline. 2004. "The State of Asthma in America: a Landmark Survey". http://www.asthmainamerica.com/ last accessed 3-12-05.

20 Martinez FD. Development of wheezing disorders and asthma in preschool children. Pediatrics. 2002;109(2 Suppl):362-7.

21 LethbridgeÇejkuM, SchillerJS, BernadelL. Summary health statisticsfor U.S. Adults: National Health Interview Survey, 2002. National Center for Health Statistics.Vital Health Stat 10(222). 2004

22 National Center for Health Statistics. Asthma Prevalence, Health Care Use and Mortality, 2002. http://www.cdc.gov/nchs/products/pubs/pubd/hestats/asthma/asthma.htm. Last accessed 3/12/05.

23 CDC. Self-Reported Asthma Prevalence Among Adults ---United States, 2000. MMWR 2001;50(32):682-6. Available at <http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5032a3.htm>.

24 Bjornson CL, Mitchell I. Gender differences in asthma in childhood and adolescence. Journal of Gender-Specific Medicine. 2000. Nov-Dec;3(8):57-61.

25 Anderson HR, Pottier AC, Strachan DP. Asthma from birth to age 23: incidence and relation to prior and concurrent atopic disease. Thorax 1992; 47(7):537-42.

26 Dodge R, Cline MG, Burrows B. Comparisons of Asthma, Emphysema, and Chronic Bronchitis diagnosis in a general population sample. Am Rev Respir Dis 1986; 133:981-986.

27 De Marco R, Locatelli F, Sunyer J, Burney P. Differences in incidence of reported asthma related to age in men and women. Am J Respir Crit Care Med 2000; 162:68-74.

28 Chen Y, Dales R, Tang M, Krewski D. Obesity may increase the incidence of asthma in women but not in men: longitudinal observations from the Canadian national population health surveys. American Journal of Epidemiology 2002; 155:191-197.

29 Troisi RJ, Speizer FE, Rosner B, Trichopoulos D, Willett WC. Cigarette Smoking and incidence of chronic bronchitis and asthma in women. Chest 1995; 108:1557-61.

30 Skobeloff EM, Spivey WH, St Clair SS, Schoffstall JM. The influence of age and sex on asthma admissions. JAMA. 1992;268(24):3437-40.

31 De Marco R, Locatelli F, Sunyer J, Burney P. Differences in incidence of reported asthma related to age in men and women. Am J Respir Crit Care Med 2000; 162:68-74.

32 Pagtakhan RD, Bjelland JC, Landau LI, Loughlin G, Kaltenborn W, Seeley G, Taussig LM. Sex differences in growth patterns of the airways and lung parenchyma in children. J Appl Physiol: Respirat. Environ. Exercise Physiol 1984; 56(5):1204-1210.

33 CDC. Self-Reported Asthma Prevalence Among Adults ---United States, 2000. MMWR 2001;50(32):682-6. Available online at http://www.cdc.gov/mmwr/preview/mmwrhtml/mm5032a3.htm .

34 Dodge RR, Burrows B. The prevalence and incidence of asthma and asthma-like symptoms in a general population sample. Am Rev Respir Dis 1980; 122(4):567-75.

35 Venn A, Lewis S, Cooper M, Hill J, Britton J. Questionnaire study of effect of sex and age on the prevalence of wheeze and asthma in adolescence. BMJ 1998;316: 1945-1946.

36 Barr RG, Wentowski CC, Grodstein F, et al. Prospective Study of postmenopausal hormone use and newly diagnosed asthma and chronic obstructive pulmonary disease. Arch Intern Med. 2004;164:379-386.

37 Zimmerman JL, Woodruff PG, Clark S, Camargo CA. Relation between phase of menstrual cycle and emergency department visits for acute asthma. Am J Respir Crit Care Med 2000; 162:512-515.

38 Luder E, Ehrlich RI, Lou WYW, Melnik TA, Kattan M. Body mass index and the risk of asthma in adults. Respiratory Medicine 2004; 98:29-37.

39 Mutius Ev, Schwartz J, Neas LM, Dockery D, Weiss ST. Relation of body mass index to asthma and atopy in children: the national health and nutrition examination study III. Thorax 2001; 56:835-838.

40 Thomson CC, Clark S, Camargo CA. Body mass index and asthma severity among adults presenting to the emergency department. Chest 2003; 124:795-802.

41 Guerra S, Sherrill DL, Bobadilla A, Martinez FD, Barbee RA. The relation of body mass index to asthma, chronic bronchitis, and emphysema. Chest 2002:122:1256-1263.

42 Varraso R, Siroux V, Maccario J, Pin I, Kauffmann F. Asthma severity is associated with body mass index and early menarche in women. AJRCCM 2004 (in press).

43 Hancox RJ, Milne BJ, Poulton R, Taylor DR, Greene JM, McLachlan CR, Cowan JO, Flannery EM, Herbison GP, Sears MR. Sex differences in the relation between body mass index and asthma and atopy in a birth cohort. AJRCCM 2004 (in press)

44 Redline S. Challenges in Interpreting Gender Differences in Asthma. Am J Respir Crit Care Med 1994; 150:1219-1221.

45 Wormald PJ. Age-sex incidence in symptomatic allergies: an excess of females in the child-bearing years. J Hyg, Camb. 1977;79:39-42.

46 Enright PL, McClelland RL, Newman AB, Gottlieb DJ, Lebowitz MD. Underdiagnosis and undertreatment of asthma in the elderly. Chest 1999;116:603-613.

47 Martinez FD, Wright AL, Taussig LM, Holberg CJ Halonen M, Morgan WJ, et al. Asthma and wheezing in the first six years of life. NEJM 1995; 332:133-138.

48 Schatz M, Camargo CA. The relationship of sex to asthma prevalence, health care utilization, and medications in a large managed care organization. Ann Allergy Asthma Immunol 2003; 91:553-558.

49 Singh AK, Cydulka RK, Stahmer SA, Woodruff PG, Camargo CA. Sex differences among adults presenting to the emergency department with acute asthma. Arch Intern Med 1999; 159:1237-1243.

50 Griffith KA, Sherrill DL, Siegel EM, Manolio TA, Bonekat HW, Enright PL. Predictors of lung function in the elderly. Am J Respir Crit Care Med 2001;163:61-68.

51 Mcwhorter WP, Polis MA, Kaslow RA. Occurrence, predictors, and consequences of adult asthma in NHANESI and follow-up survey. Am Rev Respir Dis 1989; 139:721-24.

52 Dey AN, Bloom B. Summary health statistics for U.S. children: National Health Interview Survey, 2003. National Center for Health Statistics. Vital Health Stat 10(223). 2005.

53 McConnochie KM, Russo MJ, McBride JT, Szilagyi PG, Brooks AM, Roghmann KJ. Socioeconomic variation in asthma hospitalization: excess utilization or greater need? Pediatrics 1999; 103:e75.

54 Boudreaux ED, Emond SD, Clark S, Camargo CA. Acute asthma among adults presenting to the emergency department: the role of race/ethnicity and socioeconomic status. Chest 2003;124(3):803-812.

55 Milton B, Whitehead M, Holland P, Hamilton V. The social and economic consequences of childhood asthma across the lifecourse: a systematic review. Child: Care, Health & Development 2004;30:711-728.

56 Newacheck PW, Halfon N. Prevalence, impact, and trends in childhood disability due to asthma. Arch Pediatr Adolesc Med 2000;154:287-293.

57 NHLBI Working Group. Respiratory Diseases Disproportionately Affecting Minorities. Chest 1995;108:1380-92.

58 Kattan M, Mitchell H, Eggleston P, Gergen P, Crain E, Redline S, et al. Characteristics of inner-city children with asthma: The National Cooperative Inner-City Asthma Study. Pediatr Pulmonol 1997;24:253-62.

59 Maher JE, Boysun MJ, Rohde K, Stark MJ, Pizacani BP, Dilley J, Mosbaek CH, Pickle KE. Are Latinos really less likely to be smokers? Lessons from Oregon. Nicotine & Tobacco Research. 2005. 7(2):283-87.

60 Fagan JK, Scheff PA, Hryhorczuk D, Ramakrishnan V, Ross M, et al. Prevalence of asthma and other allergic diseases in an adolescent population: Association with gender and race. Annals Allerg Asthm Immunol 2001;177-184.

61 Wade, S.; Weil, C.; Holden, G.; et al. Psycho social characteristics of inner-city children with asthma: A description of the NCICAS psychosocial protocol. National Cooperative Inner-City Asthma Study. Pediatric Pulmonology 24:263-276, 1997.

62 American Lung Association Fact Sheet: Asthma and African Americans. Available at: http://www.lungusa.org/site/pp.asp?c=dvLUK9O0E&b=308858. Last accessed: 4/29/04.

63 Stout JW, Sullivan M, Liu LL, Grossman DC. Asthma prevalence among American Indian and Alaska Native Children. Public Health Reports 1999;257-261.

64 Lewis TC, Stout JW, Martinez P, et al. Prevalence of asthma and chronic respiratory symptoms among Alaska Native Children. Chest 2004; 125:1665-1673.

65 Hisnanick JJ, Coddington DA, Gergen PJ. Trends in asthma-related admissions among American Indian and Alaskan Native children from 1979 to 1989. Universal health care in the face of poverty. Arch Pediatr Adolesc Med 1994; 148(4):357-63.

66 Liu LL, Stout JW, Sullivan M, Solet D, Shay DK, Grossman DC. Asthma and bronchiolitis hospitalizations among American Indian children. Arch Pediatr Adolesc Med 2000; 154(10):991-6.

67 Washington State Office of Finance Management (OFM), Census 2000 and 2003 intercensal estimate updates.. available at http://www.ofm.wa.gov/news/release/2004/093004.htm (last accessed 5-2-05).

68 Perez-Stable EJ, Ramirez A, Villareal R, Talavera GA, Trapido E, Suarez L, et al. Cigarette smoking behavior among US Latino men and women from different countries of origin. Am J Public Health 2001;91:1424-30.

69 Centers for Disease Control and Prevention, Office of Minority Health. "Hispanic or Latino Populations" data overview. http://www.cdc.gov/omh/Populations/HL/hl.htm (last accessed 6-15-05).

70 Perez-Perdomo R, Perez-Cardona C, Disdier-Flores O, Cintron Y. Prevalence and correlates of asthma in the Puerto Rican population : Behavioral Risk Factor Surveillance System, 2000. J Asthma 2003;40:465-74.

71 Dilley JA, Maher JE, Boysun MJ, PIzacani BA, Mosbaek CH, Rohde K, Stark MJ, Simmons KW, Pickle KE. Cigarette Smoking Among Lesbians, Gays, and Bisexuals: How Serious a Problem? (United States) [response letter to Tang, et al.]. Cancer Causes Control. (accepted for publication 5-05)

72 Aligne CA, Auinger P, Byrd RS, Weitzman M. Risk factors for pediatric asthma. Am J Respir Crit Care Med 2000; 162:873-77.

73 Rona RJ. Asthma and poverty. Thorax 2000;55:239-244.

74 Partridge MR. In what way may race, ethnicity or culture influence asthma outcomes? Thorax 2000; 55:175-176.

75 Higgins MW, Keller JB, Metzner HL. Smoking, socioeconomic status, and chronic respiratory disease. American Review of Respiratory Disease 1977; 116:403-410.

76 Vesterinen E, Kaprio J, Koskenvuo M. Prospective study of asthma in relation to smoking habits among 14,729 adults. Thorax 1988;43:534-539.

77 Siroux V, Pin I, Oryszczyn MP, Moual NL, Kauffmann F. Relationships of active smoking to asthma and asthma severity in the EGEA study.

78 Flodin U, Jonsson P, Ziegler J, Axelson O. An epidemiologic study of bronchial asthma and smoking. Epidemiology 1995;6:503-505.

79 Langhammer A, Johnsen R, Holmen J, Gulsvik A, Bjerner L. Cigarette smoking gives more respiratory symptoms among women than among men. J Epidemiol Community Health 2000;54:917-922.

80 Althuis MD, Sexton M, Prybylski D. Cigarette smoking and asthma symptom severity among adult asthmatics. Journal of Asthma 1999;36:257-264.

81 Distefan JM, Gilpin EA, Choi WS, Pierce JP. Parental influences predict adolescent smoking in the United States. Journal of Adolescent Health 1998;22:466-474.

82 Evans D, Levison MJ, Feldman CH, Clark NM, Wasilewski Y, Levin B, et al. The impact of passive smoking on emergency room visits of urban children with asthma. Am Rev Respir Dis 1987;135(3):567-72.

83 Murray AB, Morrison BJ. Passive smoking and the seasonal difference in severity of asthma in children. Chest 1988;94(4):701-8.

84 Ehrlich RI, Toit DD, Jordaan E, et al. Risk factors for childhood asthma and wheezing. Am J Respir Crit Care Med 1996;154:681-688

85 Gilliland FD, Yu-Fen L, Peters JM. Effects of maternal smoking during pregnancy and environmental tobacco smoke on asthma and wheezing in children. Am J Respir Crit Care Med 2001;163:429-436.

86 Cook DG, Strachan DP. Summary of effects of parental smoking on the respiratory health of children and implications for research. Thorax 1999;54:357-366

87 Weitzman M, Gortmaker S, Walker DK, Sobol A. Maternal smoking and childhood asthma. Pediatrics 1990;85(4):502-11.

88 Li YF, Gilliland FD, Berhane K, et al. Effects of In Utero and environmental tobacco smoke exposure on lung function in boys and girls with and without asthma. Am J Respir Crit Care Med 2000;162:2097-2104.

89 Washington State Department of Health Center for Health Statistics – Birth Data. Available at: http://www.doh.wa.gov/ehsphl/chs/chs-data/birth/bir_main.htm. Last accessed 4/30/05.

90 US Department of Health and Human Services. The Health Benefits of Smoking Cessation. USDHHS, Public Health Service, Centers for Disease Control, Center for Chronic Disease Prevention and Health Promotion, Office on Smoking and Health. DHHS Publication No. (CDC) 90-8416. 1990.

91 Camargo CA, Weiss ST, Zhang S, Willett WC, Speizer FE. Prospective study of body mass index, weight change, and risk of adult-onset asthma in women. Arch Intern Med 1999; 159:2582-2588.

92 Shaheen SO. Obesity and asthma: cause for concern? Clinical and Experimental Allergy 1999; 29:291-293

93 Huang SL, Shiao G, Chou P. Association between body mass index and teenage girls in Taiwan. Clinical and Experimental Allergy 1999;29:291-3.

94 Stenius-Aarniala B, Poussa T, Kvarnstrom J, Gronlund E, Ylikahri M, Mustjoki P. Immediate and long-term effects of weight reduction in obese people with asthma: Randomized controlled trial. British Medical Journal 2000;320:827-32.

95 Washington State Behavioral Risk Factor Surveillance system. Available at: http://www.doh.wa.gov/EHSPHL/CHS/CHS-Data/brfss/brfss_homepage.htm Last accessed 4/30/05.

96 National Institute on Drug Abuse. NIDA Research Report: Inhalant abuse. NIH Publication Number 00-3818. March 2004. US DHHS National Institutes of Health. Available at http://www.nida.nih.gov/ResearchReports/Inhalants/Inhalants.html.

97 U.S. Consumer Product Safety Commission. A Parent's Guide to Preventing Inhalant Abuse. Available at http://www.cpsc.gov/cpscpub/pubs/389.pdf.

98 Center for Substance Abuse Treatment. Substance Abuse Treatment Advisory: Inhalants. Volume 3, Issue 1, March 2003. US DHHS Substance Abuse & Mental Health Services Administration. Available at http://www.health.org/govpubs/ms922/.

99 Huss K, Naumann PL, Mason PJ, Nanda JP, Huss RW, Smith CM, Hamilton RG. Asthma severity, atopic status, allergen exposure and quality of life in elderly persons. Ann Allergy Asthma Immunol. 2001 May;86(5):524-30.

100 Rogers L, Cassino C, Berger KI, Goldring RM, Norman RG, Klugh T, Reibman J. Asthma in the elderly: cockroach sensitization and severity of airway obstruction in elderly nonsmokers. Chest. 2002 Nov;122(5):1580-6.

101 Crawford WW, Gowda VC, Klaustermeyer WB. Age Effects on Objective Measures of Atopy in Adult Asthma and Rhinitis. Allergy and Asthma Proceedings. 2004;25(3):175-9.

102 University of Washington, Center for Genomics and Public Health. Asthma Genomics: Implications for Public Health. A report commissioned by the Centers for Disease Control and Prevention. March 2004.

103 Evans, D.; Mellins, R.; Lobach, K.; et al. Improving care for minority children with asthma: Professional education in public health clinics. Pediatrics 99:157-164, 1997.

104 Institute of Medicine. Clearing the Air: Asthma and Indoor Air Exposures. Washington, DC: National Academy Press, 2000.

105 National Asthma Education and Prevention Program. Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma. NIH Pub. No. 97-4051. Bethesda, MD: NIH, 1997.

106 Moorman, Jeanne. Senior Epidemiologist, CDC Asthma Surveillance. Presentation from CDC National Asthma Conference. National Jewish Medical Center, Denver CO. February 2005.

107 National Heart, Lung and Blood Institute (NHLBI). Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma. Bethesda, MD. National Heart, Lung, and Blood Institute; 1997.

108 Fuhlbrigge AL, Adams RJ, Guilbert TW, Grant E, Lozano P, Janson SL, Martinez F, Weiss KB, Weiss ST. 2002. The burden of asthma in the United States: Level and distribution are dependent on interpretation of the National Asthma Education and Prevention Program guidelines. American Journal of Respiratory and Critical Care Medicine. 166:1044-49.

109 National Heart, Lung and Blood Institute (NHLBI). Expert Panel Report 2: Guidelines for the Diagnosis and Management of Asthma. Bethesda, MD. National Heart, Lung, and Blood Institute; 1997.

110 CDC NCHS 1998 National Health Interview Survey, as cited in Department of Health & Human Services. Healthy People 2010. 2nd ed. Washington, DC: U.S. Government Printing Office, Nov 2000: page 24-18.

111 Washington State Department of Health, Center for Health Statistics. 2002 Death Certificates. Released 10/03. available at: http://www.doh.wa.gov/ehsphl/chs/chs-data/death/2002/2002c2.htm last accessed 3-12-05.

112 Regional Code of Washington (RCW) 28A.210.320. Children with life-threatening health conditions. Washington Administrative Code (WAC) 180-38-045. School attendance conditioned upon presentation of proofs.

113 Etzel RA. How environmental exposures influence the development and exacerbation of asthma. Pediatrics. July 2003;112(1):233-39.

114 Luginaah IN, Fung KY, Gorey KM, Webster G, Wills C. Association of ambient air pollution with respiratory hospitalization in a government-designated "area of concern": the case of Windsor, Ontario. EHP 2005;113(3): 290-296.

115 Yang Q, Chen Y, Shi Y, Burnett RT, McGrail KM, Krewski D. Association between ozone and respiratory admissions among children and the elderly in Vancouver, Canada. Inhalation Toxicoly 2003;15(13): 1297-13208.

116 Yu O, Sheppard L, Lumley T, Koenig JQ, Shapiro GG. Effects of ambient air pollution on symptoms of asthma in Seattle –Area children enrolled in the CAMP study. EHP 2000;10812) 1209-1214.

117 Norris G, Larson T, Koenig J, Clairborn C, Sheppard L, Finn D. Asthma aggravation, combustion, and stagnant air. Thorax 2000;55:466-470.

118 Slaughter JC, Lumley T, Sheppard L, Koenig JQ, Shapiro GG. Effects of ambient air pollution on symptom severity and medication use in children with asthma. Ann Allergy Asthma Immunol 2003; 91: 346-353.

119 Peel JL, Tolbert PE, Klein M, Metzger KB, Flanders WD, Todd K, Mulholland JA, Ryan PB, Frumkin H. Ambient air pollution and respiratory emergency department visits. Epidemiology 2005;16(2): 164—174.

120 Avol EL, Gauderman WJ, Tan, SM, London SJ, Peters JM. Respiratory effects of relaocting to areas of differing air pollution levels. Am J Crit Care Med 2001;164: 2067-2072.

121 McConnell R, Berhane K, Filliland F, London SJ, Vora H, Avol E, Gauderman WJ, Margolis HG, Lurmann F, Thomas DC, Peters JM. Air pollution and bronchitic symptoms in Southern California children with asthma. Environmental Health PErspctives. Sepbember 1999;107(9):757-60.

122 Yu O, Sheppard L, Lumley T, Koenig JQ, Shapiro GG. Effects of Ambient Air Pollution on Symptoms of Asthma in Seattle – Area children enrolled in the CAMP study. Environmental Health Perspectives. Dec 2000;108(12):1209-1214.

123 Gauderman WJ, McConnell R, Gilliland F, London S, Thomas D, Avol E, Vora H, Berhane K, Rappaport EB, Lurmann F, Margolis HG, Peters J. Association between air pollution and lung function grown in Southern California Children. Am J Respir Crit Care Med. 2000;162:1383-90.

124 Avol EL, Gauderman WJ, Tan SM, London SJ, Peters JM. Respiratory effects of relocating to areas of differing air pollution levels. Am J of Respiratory and Criitcal Care Medicine. December 2001;164(11):2067-72.

125 McConnell R., Berhane K, Gilliland F, London SJ, Islam T, Gauderman WJ, Avol E, Margolis HG, Peters JM. Asthma in exercising children exposed to ozone: a cohort study. Lancet. 2002;359:386-91.

126 Gauderman WJ, Gilliland GF, Vora H, Avol E, Stram D, McConnell R, Thomas D, Lurman F, Margolis HG, Rappaport EB, Berhane K, Peters JM. Association between air pollution and lung function growth in southern California children. American Journal of Respiratory and Critical Care Medicine 2002;166: 76-84.

127 Tolbert PE, Mulholland JA, MacIntosh DL, Xu F, Devine DD, Carlin BP, Klein M, Dorley J, Butler AF, Nordenberg DF, Frumkin H, Ryan PB, White MC. Air quality and pediatric emergency room visits for asthma in Atlanta, Georgia. Am J Epidemology. 2000;151(8):798-810.

128 Sheppard L, Levy D, Norris G, Larson TV, Koenig JQ. 1999 Effects of ambient air pollution on nonelderly asthma hospital admissions in Seattle, WA, 1987-1994. Epidemiology 10:23-30

129 Environmental Protection Agency "Air Now" http://www.epa.gov/airnow/

130 Institute of Medicine. Damp Indoor Spaces and Health. Washington DC: National Academies Press; 2004. Available online at http://www.nap.edu/catalog/11011.html.

131 Abulhosn RS, Morray BH, Llewellyn CE, Redding GJ. Passive smoke exposure impairs recovery after hospitalization for acute asthma. Arch Pediatr Adolesc Med 1997;151:135-9.

132 Strachan DP, Cook DG. Parental smoking and childhood asthma: longitudinal and case-control studies. Thorax 1998;53:204-212.

133 Greer JR, Abbey DE, Burchette RJ. Asthma related to occupational and ambient air pollutants in nonsmokers. J Occup Med 1993;35:909-15.

134 Ng TP, Hui KP, Tan WC. Respiratory symptoms and lung function effects of domestic exposure to tobacco smoke and cooking by gas in non-smoking women in Singapore. J Epidemiol Community Health 1993; 47:454-8.

135 Leuenberger P, Schwartz J, Ackermann-Liebrich U, et al. Passive smoking exposure in adults and chronic respiratory symptoms (SAPALDIA Study). Swiss study on air pollution and lung diseases in adults, SAPALDIA team. Am J Respir Crit Care Med 1994;150:1222-8.

136 Hu FB, Persky V, Flay BR, Zelli A, Cooksey J, Richardson J. Prevalence of asthma and wheezing in public schoolchildren: association with maternal smoking during pregnancy. Ann Allergy Asthma Immunol 1997;79:80-84.

137 Thorn J, Brisman J, Toren K. Adult-onset asthma is associated with self-reported mold or environmental tobacco smoke exposures in the home. Allergy 2001;56:287-92.

138 Jaakkola MS, Piipari R, Jaakkola N, Kaakkola JJK. Environmental tobacco smoke and adult-onset asthma: a population-based incident case-control study. Am J Public Health 2003;93:2055-2060.

139 Beckett WS. (2002). Revised Protocol: Criteria for Designating Substances as Occupational Asthmagens on the AOEC List of Exposure Codes. Accessed from: <http://www.aoec.org/Asthmagen_Pro-7-25-02.pdf on January 24>, 2005.

140 National Survey of Public Perceptions of Environmental Health Risks – Washington Component. Princeton Survey Research Associates, Pew Charitable Trusts, Georgetown University. 2000. Available at: http://healthyamericans.org/docs/index.php?DocID=18 last accessed 3-12-05.

141 Washington State Department of Ecology. Washington's Environmental Health 2000. Air Quality. Pub 00-01-003. http://www.ecy.wa.gov/pubs/0001003/index.html (last accessed 6-15-05)

142 Washington State Department of Ecology. 2000-2002 Air Quality Trends. April 2003. Available at http://www.ecy.wa.gov/pubs/0302008.pdf (last accessed 3-22-05)

143 Puget Sound Clean Air Agency. www.pscleanair.org

144 Prill R, Blake D, Hales D. School Indoor Air Quality Assessment and Program Implementation. Washington State University and Northwest Air Pollution Authority. Available at: http://www.energy.wsu.edu/projects/building/iaq.cfm (last accessed 6-15-05)

145 Shendell DG, Prill R, Fisk WJ, Apte MG, Blakc D, Faulkner D. Associations between classroom CO2 concentrations and student attendance in Washington and Idaho. Indoor Air. 2004;14:333-341.

146 Washington State Department of Ecology. Washington State Clean School Bus Program, 2005 Report to the Legislature. Available at: http://www.ecy.wa.gov/pubs/0402029.pdf

(last accessed 5-2-05)

147 Blanc PD, Toren K. How much adult asthma can be attributed to occupational factors ? American Journal Medicine 1999;107:580-587.

148 Mannino DM. How much asthma is occupationally related? Occupational Medicine 2000; 15:359-68.

149 Schwartz, D.A., and Peterson, M.W. Occupational lung disease. Advances in Internal Medicine 42:269-312, 1997.

150 Venables KM, Chan-Yeung M. Occupational asthma. Lancet. 1997;349:1465-9.

151 Krieger JW, Song L, Takaro TK, Stout J. Asthma and the home environment of low-income urban children: preliminary findings from the Seattle-King County healthy homes project. Journal of Urban Health. 2000;77:50-67.

152 Krieger J, Takaro TK, Allen C, Song L, Weaver M, Chai S, Dickey P. The Seattle-King County Healthy Homes Project: implementation of a comprehensive approach to improving indoor environmental quality for low-income children with asthma. Environmental Health Perspectives. 2002;110(S2):311-22.

153 Krieger JW, Takaro TK, Song L, Weaver M. The Seattle-King County healthy homes project: a randomized, controlled trial of a community health worker intervention to decrease exposure to indoor asthma triggers. AJPH. 2005;95(4):652-9. Data provided by Lin Song 12-04 as combined baseline data from both intervention and control groups in this study.

154 John Thayer. Yakima Valley Farm Workers Clinic, Childhood Asthma Project Coordinator.. Personal communication, 6-05.

155 Cook DG, Strachan DP. Parental smoking and prevalence of respiratory symptoms and asthma in school age children. Thorax 1997;52:1081-94.

156 Strachan DP, Cook DG. Parental smoking and childhood asthma: longitudinal and case-control studies. Thorax 1998;53:204-212

157 Hazardous Waste and Toxics Reduction Program. A Study of Environmental Equity in Washington State. Washington State Department of Ecology. 1995 Oct. Available from: http://www.ecy.wa.gov/pubs/95413.pdf (last accessed 5-2-05)

158 Korenstein S, Piazza B. An exposure assessment of PM10 from a major highway interchange: are children in nearby schools at risk?. J Environ Health 2003;65(2):9-17.

159 Washington State Board of Health. Carl Osaki, Joe Finkbonner Ed. Final Report State Board of Health Priority: Environmental Justice. June 2001.